MALCOLM PIRNIE

MALCOLM PIRNIE, INC.
INDEPENDENT ENVIRONMENTAL ENGINEERS, SCIENTISTS & CONSULTANTS

April 7, 2005

Ms. Alice Yeh
Remedial Project Manager
U.S. Environmental Protection Agency - Region 2
290 Broadway, 19th Floor
New York, NY 10007

Re: Draft Work Plan
Lower Passaic River Restoration Project Superfund Site

Dear Ms. Yeh:

Enclosed are two (2) copies of the Draft Work Plan for the Lower Passaic River Restoration Project. Hard copies of this document have been distributed as directed and an electronic version of this document will be posted on PREmis.

We appreciate the opportunity to work with you. Please call me at (201) 398-4365 if you have any questions.

Very truly yours,

MALCOLM PIRNIE, INC.

Bruce Fidler

Bruce Fidler, P.E.
Project Manager

enclosures

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Lower Passaic River Restoration Project

Draft
Work Plan

April 2005

PREPARED BY:
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White Plains, NY 10602

FOR:
US Environmental Protection Agency
Region II

US Army Corps of Engineers
Kansas City District
Contract No.
DACW41-02-D-0003

LOWER PASSAIC RIVER RESTORATION PROJECT
DRAFT WORK PLAN

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1.0 INTRODUCTION

1.1 OVERVIEW

This Work Plan (WP) presents the technical approach for conducting sampling and investigation activities for the Lower Passaic River Restoration Project (LPRRP), which includes a Remedial Investigation/Feasibility Study (RI/FS) under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), and a Water Resources Development Act (WRDA) FS. This WP is a dynamic document that will be amended as the project evolves and additional phases of work are initiated.

The LPRRP Study Area (hereafter referred to as the Study Area) encompasses the 17-mile tidal reach of the Passaic River below the Dundee Dam, including the tidal portion of its tributaries (*e.g.*, Saddle River, Second River, and Third River). Refer to Figure 1-1 for a Site Location Map. The Study Area also includes the major physically connected water bodies, including the Hackensack River up to the Oradell Dam, Berry's Creek, Pierson Creek, Newark Bay, the Arthur Kill, and the Kill van Kull.

Figure 1-1: LPRRP – Site Location Map

1.2 LPRRP INVESTIGATION PURPOSE AND OBJECTIVES

The objectives of the LPRRP investigation work activities are to:

- Obtain data to prepare the combined CERCLA RI/FS and WRDA FS report for the LPRRP.
- Develop human health and ecological risk assessments for the Lower Passaic River to determine whether the risk range identified in the National Contingency Plan (NCP) is exceeded and warrants further assessment of remedial actions via the FS.
- Obtain data to develop a numerical model of the Lower Passaic River within the domain of the existing Contamination Assessment and Reduction Project (CARP) model, developed for the NY/NJ Harbor Estuary Program.
- Support a comprehensive, watershed-based plan to restore the functional and structural integrity of the Lower Passaic River ecosystem and to support broader, watershed-wide restoration efforts under WRDA.
- Support development of a natural resource damage assessment (NRDA) under CERCLA by the Passaic River/Newark Bay Trustees for Natural Resources [New Jersey Department of Environmental Protection (NJDEP), U.S. Fish and Wildlife Survey (USFWS), and National Oceanic and Atmospheric Administration (NOAA)] to provide restoration for natural resources injured by contaminants and to compensate for the public's lost use of those resources.

Further discussion of the investigation objectives is provided in Section 4.0 – WP Rationale, and in the data quality objectives (DQOs) provided in the Malcolm Pirnie, Inc. (MPI) March 2005 Quality Assurance Project Plan (QAPP) (MPI, 2005a).

To date, numerous investigations, including environmental sampling, have been conducted in parts of the Lower Passaic River by various entities having differing objectives. Preliminary activities for this project focused on compiling and evaluating existing data prior to advancing with significant additional work. The results of preliminary evaluation of historical surface sediment data are included in this WP as Section 3.0 – Preliminary Evaluation.

The results of the preliminary historical data evaluation activities have been used to initiate subsequent investigation activities through completion of: this WP; the QAPP; the Field Sampling Plan (FSP); the Modeling Plan; and the Pathways Analysis Report (PAR) (Battelle, 2004a). In general, the Modeling Plan, the PAR, and the DQOs outlined in the QAPP identify data that are necessary to complete the investigations and CERCLA and WRDA feasibility studies. The FSP is comprised of three volumes. Each volume's contents and timeframe of preparation are summarized below:

- Volume 1: FSP Volume 1 (MPI, 2005b) includes investigations to characterize sediment and surface water quality in the Passaic River and in major tributaries. These investigations are being done to gain physical data necessary to complete risk assessments and to develop models. The investigations will include measurements of hydrodynamic and sediment transport characteristics of the Lower Passaic River and major tributaries.
- Volume 2: FSP Volume 2 will include investigations that relate to the biota and biological aspects of the Lower Passaic River and the surrounding watershed. Investigations are planned to include taking inventory and cataloging the species found within and around the Lower Passaic River and obtaining tissue samples to determine contamination concentrations. This volume is scheduled to be developed from Fall 2005 to Spring 2006.
- Volume 3: FSP Volume 3 (MPI, 2005c) addresses additional investigations on candidate restoration sites. The candidate restoration site investigations will include: land surveys, soils investigations, groundwater investigations, real estate research, and socioeconomic research. FSP Volume 3 also includes the necessary bathymetric and geophysical surveys for the Passaic River.

These needs are compared to the available historical data and the data gaps are identified. The required data and field tasks are then identified and described in this WP and the FSP documents. In addition to the preliminary evaluation described in Section 3 – Preliminary Evaluation, additional geochemical and sediment stability analyses are currently being conducted to update the conceptual site model (CSM) and to provide guidance in determining sampling locations for the sediment field programs described in FSP Volume 1 (MPI, 2005b). Based on ongoing evaluation of historical data, conclusions will be presented in a forthcoming technical memorandum.

As discussed in Section 1.1, field investigations will center on the 17 miles of the Lower Passaic River and its tributaries. In order to collect field data that is essential for modeling purposes, aspects of several field programs will also extend, as appropriate, into connected water bodies such as the Hackensack River and its tributaries, Newark Bay, Arthur Kill, and the Kill van Kull. This work will take into account complementary efforts being conducted by Tierra Solutions, Inc. (TSI), which is under an Administrative Order of Consent (AOC) with the United States Environmental Protection Agency (USEPA) to conduct work in Newark Bay and its tributaries, as well as work being conducted at the direction of USEPA in Berry’s Creek, a tributary of the Hackensack River.

1.3 SITE BACKGROUND AND HISTORY

The USEPA, the U.S. Army Corps of Engineers (USACE), the New Jersey Department of Transportation (NJDOT) and the New Jersey Department of Environmental Protection (NJDEP) have partnered to conduct a comprehensive study of the Lower Passaic River and its tributaries. The Lower Passaic is the 17-mile tidal stretch of the river from the Dundee Dam south to Newark Bay. The LPRRP is an integrated, joint effort among state and federal agencies that will take a comprehensive look at the problems within the Lower Passaic River Basin and identify remediation and restoration options to address those problems. This multi-year study will provide opportunities for input from the public at all phases of development.

The project's goals are to provide a plan to:

- Remediate contamination found in the river to reduce human health and ecological risks.
- Improve the water quality of the river.
- Improve and/or create aquatic habitat.
- Reduce the contaminant loading in the Passaic and the Hudson-Raritan Estuary.

1.3.1 A Brief History

The Passaic River derived its name from the Algonquin word meaning "peaceful valley". The river spans over 80 miles of suburban and urban areas from its headwaters in Morristown, NJ to its confluence with the tidal waters of Newark Bay. The Passaic River Basin drains an area of approximately 935 square miles with 787 square miles in New Jersey and 148 square miles in New York. Seven major tributaries bring water into the river's main stem, which is used for water supply, recreation, navigation and wastewater assimilation.

During the 1800s, the area surrounding the Lower Passaic River became a focal point for the nation's industrial revolution. By the 20th century, Newark had established itself as the largest industrial-based city in the country. The urban and industrial development surrounding the Lower Passaic River, combined with associated population growth, have resulted in poor water quality, contaminated sediments, bans on fish and shellfish consumption, lost wetlands, and degraded habitat. Figure 1-2 illustrates Superfund Sites on the National Priorities List (NPL) in the vicinity of the Lower Passaic

River. Figure 1-3 indicates facilities in the vicinity of the Study Area regulated pursuant to the Resource Conservation and Recovery Act (RCRA). Figure 1-4 shows locations of New Jersey Known Contaminated Sites in the vicinity of the Study Area.

Point and non-point discharges to the Lower Passaic River, including Combined Sewer Overflows (CSOs), have contributed to its contamination. Figure 1-5 illustrates CSOs in the Paterson area, and Figure 1-6 illustrates CSOs in the Newark area.

Figure 1-2: LPRRP – Superfund Sites on the NPL

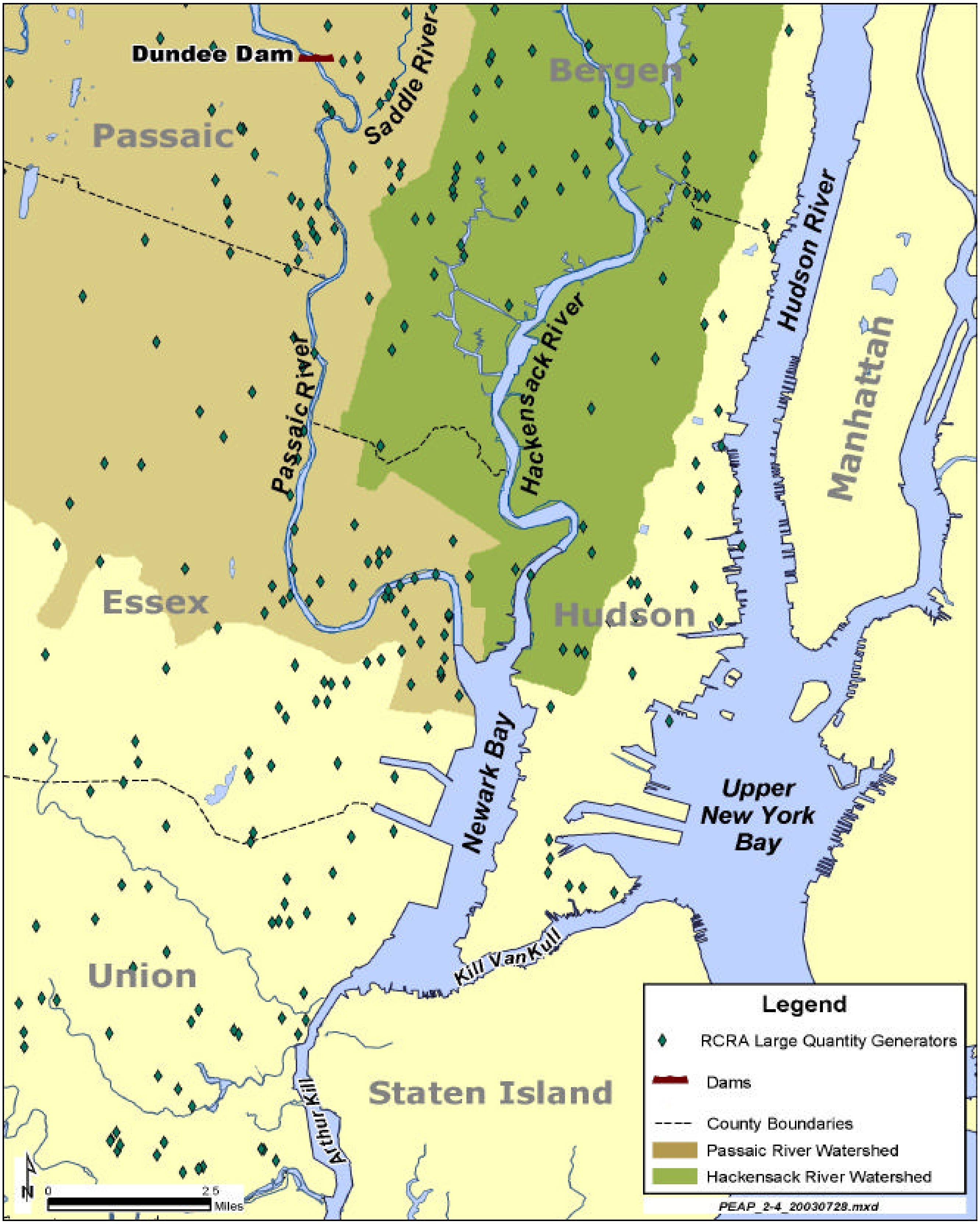


Figure 1-3: LPRRP - Regulated RCRA Facilities

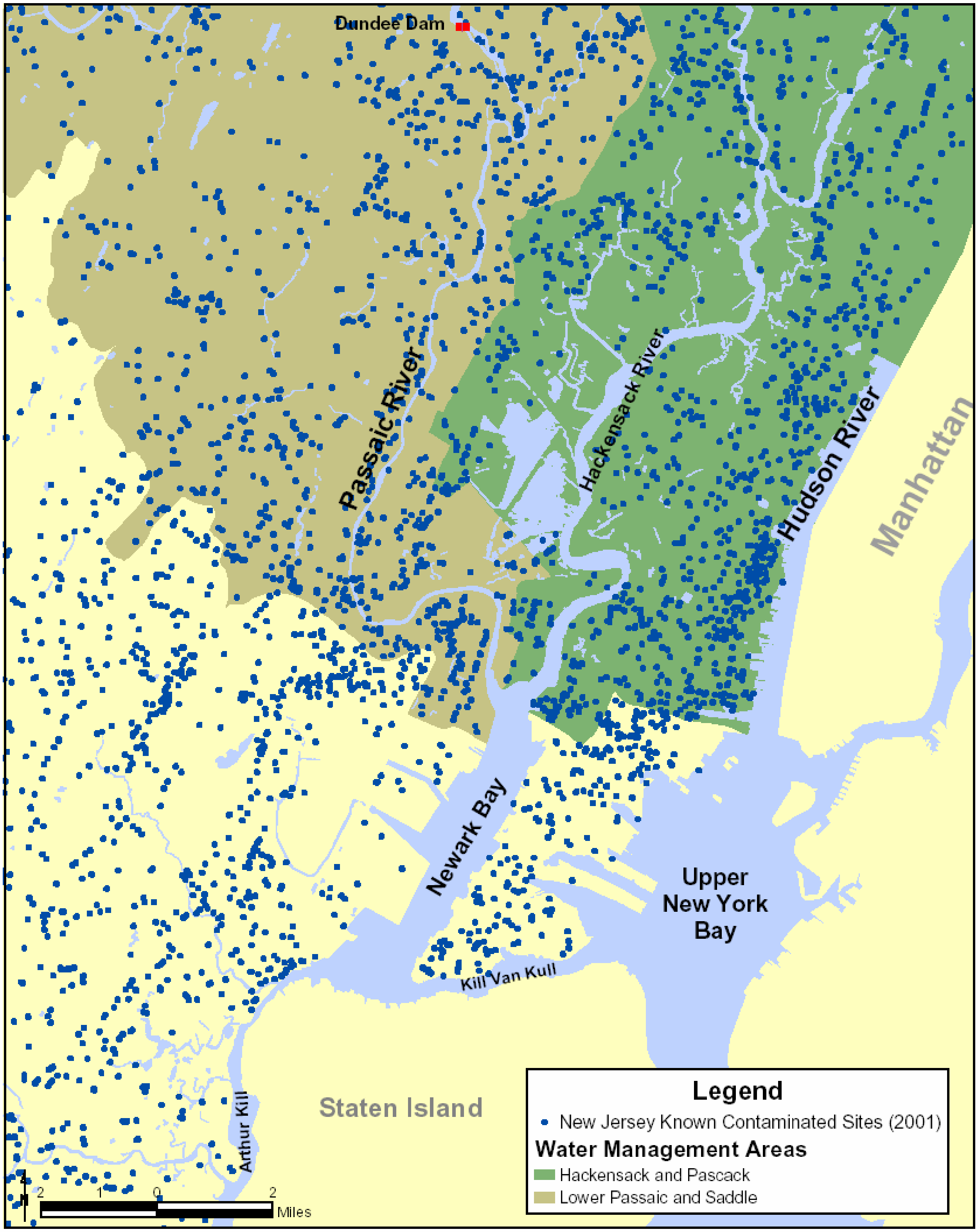


Figure 1-4: LPRRP – New Jersey Known Contaminated Sites

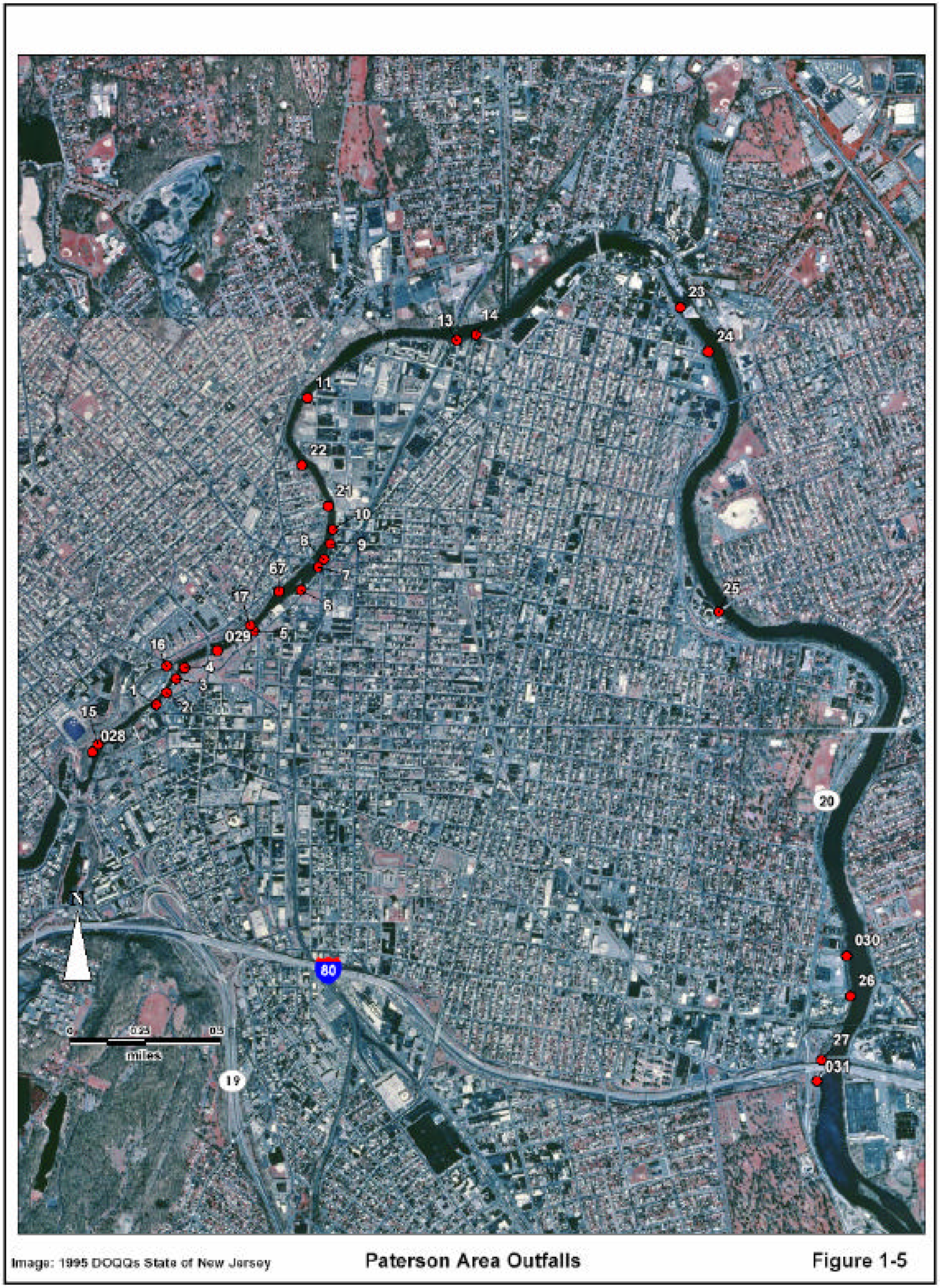


Figure 1-5: LPRRP – Paterson Outfalls

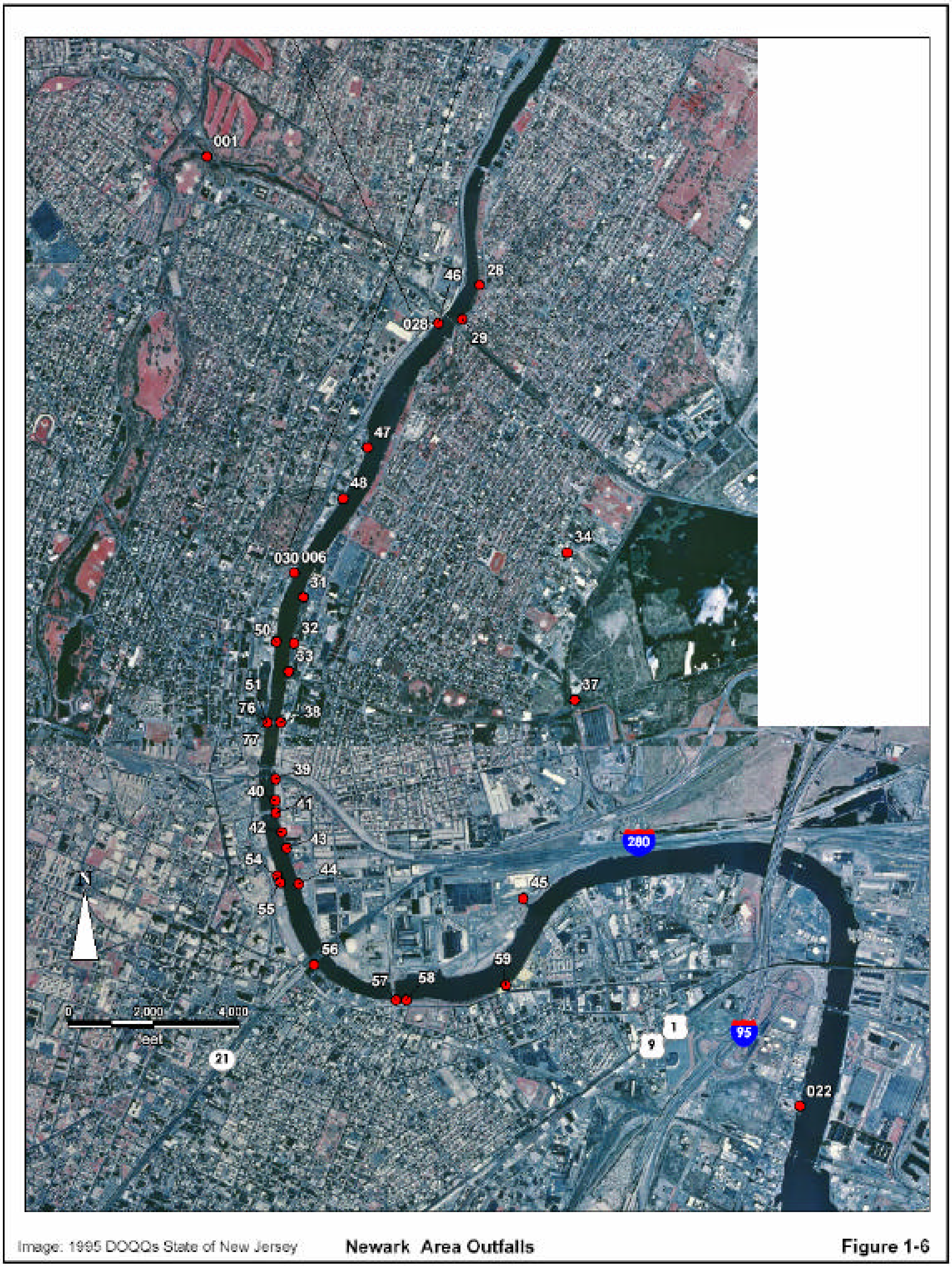


Figure 1-6: LPRRP – Newark Area Outfalls

1.3.2 Federal and State Agencies' Involvement

In the early 1980s, USEPA found soil contaminated with dioxin at the Diamond Alkali manufacturing plant in Newark, NJ, next to the Passaic River. Cleanup work was initiated and the USEPA added the site to the NPL in 1984, making it eligible for cleanup funds under the federal Superfund Program. Contaminants such as metals, persistent organic chemicals, pesticides, and dioxins were also found in the sediments of the six miles of the Lower Passaic River bordering the manufacturing plant. The contaminated sediments were analyzed and the results showed that, in some areas of the Passaic River, there were concentrations of harmful contaminants at levels that are unsafe according to federal and state standards. Some locations had levels several times higher than these standards.

Several more studies of the Passaic River by USEPA, USACE, and others showed that contaminated sediments and other sources of hazardous chemicals exist along the 17-mile tidal stretch of the Passaic River. Therefore, USEPA, USACE, and NJDOT have formed a partnership to expand the study to include the entire Lower Passaic River watershed. The partners are also coordinating with the natural resources trustees [NOAA, U.S. Fish and Wildlife Service (USFWS), and NJDEP] to include information useful to them for their assessment of injuries and related damages to natural resources associated with hazardous substances releases.

USACE's authority to conduct this study is from a U.S. Congress (House of Representatives) Resolution. Using funds from the annual Energy and Water Resources Appropriations Act, NY/NJ Joint Dredging Plan, and the Transportation Trust Fund, a nine million-dollar cost-sharing agreement to study the Lower Passaic River was signed in June 2003 between USACE and NJDOT. The remediation portion of the study will be funded under USEPA's Superfund Program, through an Administrative Order on Consent among USEPA and over 31 potentially responsible parties. Since the restoration and remediation studies have many overlapping information needs, the USACE, USEPA, and NJDOT have agreed to combine their authorities and funds to carry out a single, integrated study of the Lower Passaic River.

1.4 COMMUNITY INVOLVEMENT AND PUBLIC OUTREACH (PMP TASK JI)

Community involvement is a key component of the LPRRP. A Community Involvement Plan is being developed to guide public outreach activities for the project. Plan development started with a series of stakeholder interviews to identify community concerns and to ask how people would prefer to receive information about the project as it proceeds. While some stakeholders were more focused on either Passaic River or Newark Bay, most had an interest and concern about both. Between December 2004 and February 2005, over 50 individuals were interviewed across a diversity of interests and geographies at several different locations from Keyport to Clifton, New Jersey. Many of the stakeholders are members of organizations with an interest in the environment, local economy, environmental justice, fishing and recreation, and land preservation and sustainable development. The “common threads” that were heard among the stakeholders’ concerns and interests will be captured in a summary report, which will be the basis of the Community Involvement Plan.

2.0 SITE BACKGROUND

2.1 SITE AREA CONDITIONS

2.1.1 Geologic Setting

The Lower Passaic River is situated within the Newark Basin portion of the Piedmont physiographic Province, which is located between the Atlantic Coastal Province and the Appalachian Province. The Newark Basin is underlain by sedimentary rocks (sandstones, shales, limy shales, and conglomerates), igneous rocks (basalt and diabase), and metamorphic rocks (schists and gneiss). These rocks are from the mid-Triassic to early Jurassic periods. Bedrock underlying the Lower Passaic River is the Passaic Formation (Olsen, *et al.*, 1984; Nichols, 1968), which consists of interbedded red-brown sandstones and shales.

Almost the entire Passaic River Basin, including the Lower Passaic River, was subjected to glacial erosion and deposition as a result of the last stage of the Wisconsin glaciation. Considerable quantities of stratified sand, silt, gravel, and clay were deposited in a glacial lake covering the area. These glaciofluvial deposits overlie bedrock and underlie the Meadowlands section of the Newark Basin.

2.1.2 Surface Water Hydrology

The majority of the freshwater inflow to the Lower Passaic River [approximately 1,200 cubic feet per second (cfs) on average] is provided by the upper portion of the river (USACE, 1987; USGS, 1989). Contributing tributaries to the river's flow include gauged rivers (Saddle River, Second River, and Third River) and ungauged rivers (Frank's Creek, Lawyer's Creek, Harrison's Creek, and Plum Creek). Table 2-1 provides the river mile (RM) confluence points with these tributaries and the contributing stream flow for those rivers that are U.S. Geological Survey (USGS)-gauged (USGS, 2005).

Table 2-1: LPRRP – Tributary River Mile (RM) Confluence with the Lower Passaic River and Mean Stream Flow Contributions

Tributary	RM Confluence Point	Contributing Stream Flow in ft^3/s
Saddle River	15.6	99.4
Second River	8.1	18.3
Third River	11.3	20.7
Frank's Creek *	3.2	N/A
Lawyer's Creek *	1.8	N/A
Harrison Creek *	1.6	N/A
Plum Creek *	0.7	N/A
* Total River Miles in the Lower Passaic River = 17.4 * Note: Tributaries are not USGS gauged. Creek RMs are approximations based on NOAA charts.		

Additional sources include urban runoff, storm sewers, and CSOs (Figures 1-5 and 1-6). Details of the CSOs down-estuary of the Dundee Dam, including each CSO's name, location, and receiving water body are provided in Table 2-2 and Figures 1-5 and 1-6. According to Suszkowski (1978), the ungauged flows between the Dundee Dam and Newark Bay contribute less than 10% of the total flow at the mouth of the Passaic River. Water quality in the Lower Passaic River is rated very poor in the freshwater regime above the Dundee Dam and in the saline tidal reaches below the dam (USACE, 1987).

Table 2-2: LPRRP – Summary of CSOs in the Passaic River

CSO #	Name	Location		LONGITUDE	RECEIVING WATERBODY
1	Curtis Place	Paterson	Active	-74.17605623	PASSAIC RIVER
2	Mulberry Street	Paterson	Active	-74.17540063	PASSAIC RIVER
3	West Broadway	Paterson	Active	-74.17480113	PASSAIC RIVER
4	Bank Street	Paterson	Active	-74.17425219	PASSAIC RIVER
5	Bridge Street	Paterson	Active	-74.16987565	PASSAIC RIVER
6	Montgomery Street	Paterson	Active	-74.1668825	PASSAIC RIVER
7	Straight Street	Paterson	Active	-74.16577762	PASSAIC RIVER
8	Franklin Street	Paterson	Active	-74.16542827	PASSAIC RIVER
9	Keen Street	Paterson	Active	-74.16501875	PASSAIC RIVER
10	Warren Street	Paterson	Active	-74.16486462	PASSAIC RIVER
11	Sixth Avenue	Paterson	Active	-74.16642248	PASSAIC RIVER
13	E. 11th Street	Paterson	Active	-74.1569832	PASSAIC RIVER
14	Fourth Avenue	Paterson	Active	-74.15574227	PASSAIC RIVER
15	S.U.M. Park	Paterson	Active	-74.1797415	PASSAIC RIVER

CSO #	Name	Location		LONGITUDE	RECEIVING WATERBODY
16	Northwest Street	Paterson	Active	-74.17539027	PASSAIC RIVER
17	Arch Street	Paterson	Active	-74.17012051	PASSAIC RIVER
21	Bergen Street	Paterson	Active	-74.16514483	PASSAIC RIVER
22	Short Street	Paterson	Active	-74.16680416	PASSAIC RIVER
23	Second Avenue	Paterson	Active	-74.14280616	PASSAIC RIVER
24	Third Avenue	Paterson	Active	-74.14104983	PASSAIC RIVER
25	33rd Street & 10th Avenue	Paterson	Active	-74.14047266	PASSAIC RIVER
26	20th Avenue	Paterson	Active	-74.13224861	PASSAIC RIVER
27	Market Street	Paterson	Active	-74.13407241	PASSAIC RIVER
67	Hudson Street	Paterson	Active	-74.16826962	PASSAIC RIVER
28	Stewart Avenue	Kearny	Active	-74.14772199	PASSAIC RIVER
29	Washington Avenue	Kearny	Active	-74.14918854	PASSAIC RIVER
31	Nairn Avenue	Kearny	Active	-74.16269243	PASSAIC RIVER
32	Marshall Street	Kearny	Active	-74.16351313	PASSAIC RIVER
33	Johnston Avenue	Kearny	Active	-74.16393242	PASSAIC RIVER
34	Ivy Street	Kearny	Active	-74.14039016	FRANK'S CREEK
37	Duke Street	Kearny	Active	-74.13981581	FRANK'S CREEK
38	Central Avenue	East Newark	Active	-74.16466396	PASSAIC RIVER
39	New Street	Harrison	Active	-74.16510358	PASSAIC RIVER
40	Cleveland Street	Harrison	Active	-74.16512276	PASSAIC RIVER
41	Harrison Avenue	Harrison	Active	-74.16508007	PASSAIC RIVER
42	Dey Street	Harrison	Active	-74.16460475	PASSAIC RIVER
43	Bergen Street	Harrison	Active	-74.16417641	PASSAIC RIVER
44	Middlesex Street	Harrison	Active	-74.16316868	PASSAIC RIVER
45	Worthington Avenue	Harrison	Active	-74.14422336	PASSAIC RIVER
46	Verona Avenue	Newark	Active	-74.15121519	PASSAIC RIVER
47	Delavan Avenue	Newark	Active	-74.15723593	PASSAIC RIVER
48	Herbert Place	Newark	Active	-74.15930066	PASSAIC RIVER
50	Fourth Avenue	Newark	Active	-74.16499307	PASSAIC RIVER
51	Clay Street	Newark	Active	-74.16579839	PASSAIC RIVER
76	Passaic Street	Newark	Active	-74.16579839	PASSAIC RIVER
77	Ogden Street	Newark	Active	-74.16579839	PASSAIC RIVER
54	Rector Street	Newark	Active	-74.16498813	PASSAIC RIVER
55	Saybrook Place	Newark	Active	-74.16474564	PASSAIC RIVER
56	City Dock	Newark	Active	-74.16189875	PASSAIC RIVER
57	Jackson Street	Newark	Active	-74.15501819	PASSAIC RIVER
58	Polk Street	Newark	Active	-74.15413036	PASSAIC RIVER
59	Freeman Street	Newark	Active	-74.14573431	PASSAIC RIVER
60	Peddie Street	Newark	Active	-74.18648354	PEDDIE DITCH
61	Queens District	Newark	Active	-74.18603914	QUEEN DITCH
62	Waverly District	Newark	Active	-74.19106382	WAVERLY DITCH
63	Yantacaw Pump Station	Clifton	Relief Point	-74.13047928	THIRD RIVER
64	Yantacaw Street	Clifton	Relief Point	-74.13057626	THIRD RIVER
65	Wallington Pump Station	Wallington	Relief Point	-74.11967586	PASSAIC RIVER
66	N. Arlington Branch	North Arlington	Relief Point	-74.14613403	PASSAIC RIVER

CSO #	Name	Location		LONGITUDE	RECEIVING WATERBODY
69	Lodi Force Main	Passaic	Relief Point	-74.11997697	PASSAIC RIVER
70	Passaic Tail Race	Passaic	Relief Point	-74.11982333	PASSAIC RIVER
75	2nd River Joint Meeting	Newark	Relief Point	-74.15071787	PASSAIC RIVER
001	Meadowbrook	Newark	Active	-74.17067965	Second River
006	Oriental	Newark	Active	-74.11888586	Passaic River
022	Roanoke	Newark	Active	-74.12096986	Newark Bay
023	Adams	Newark	Active	-74.16860515	Adams Ditch
024 & 030	Wheeler / Avenue A	Newark	Active	-74.18023238	Wheeler Ditch
	Newark Airport Peripheral Ditch	Newark		-74.15972907	Flows into Elizabeth Channel
028	Sum Park 2	Paterson	Active	-74.18009014	PASSAIC RIVER
029	Loop Road	Paterson	Active	-74.17215995	PASSAIC RIVER
030	19th Avenue	Paterson	Active	-74.13247222	PASSAIC RIVER
031	Route 20 Bypass	Paterson	Active	-74.13438519	PASSAIC RIVER

The Lower Passaic River is influenced by tidal flows for approximately 17 miles extending from Dundee Dam down-estuary to the confluence with Newark Bay. The mean tidal range [difference in height between mean high water (MHW) and mean low water (MLW)] at the New Jersey Turnpike Bridge (approximately RM 2.4) is 5.1 feet (NOAA, 1972) with a mean tide level (midway between MLW and MHW) at elevation 2.5 feet (NOAA, 1972). The mean spring tide range (average semi-diurnal range occurring during the full and new moon periods) is 6.1 feet. The salt wedge is found within the Harrison Reach. The cross-sectional average river velocity due to freshwater flow in the Lower Passaic River is approximately 1 foot per second with a typical maximum tidal velocity of approximately 3 feet per second (USACE, 1987). The velocities resulting from up-estuary freshwater flow conditions will not normally control the resuspension of bottom sediments (USACE, 1987).

2.1.3 Climate

The information provided by USACE (1987) indicates that the climate for the Lower Passaic River and surrounding area is characteristic of the Middle Atlantic Seaboard where marked changes in weather are frequent, particularly in the spring and fall. Winters are moderate with snowfall averaging approximately 34 inches annually from October through mid-April. Rainfall is moderate and distributed fairly uniformly throughout the year, averaging approximately 47 inches annually with an average of 121 rainy days per year, although the region may be influenced by seasonal tropical storms and hurricanes between June and November. Thunderstorm activity is most likely to occur in the summer. Northeasters usually occur from November to April; these events usually bring strong northeast winds over the East Coast as they move northward along the Atlantic Coast, leading to heavy rain, snow, and coastal flooding. The average annual temperature in Newark is 54 degrees Fahrenheit (^{o}F) with extremes from -26^{o}F to +108^{o}F. Mean relative humidity varies from 67% to 73%. Prevailing winds in the Newark area are from the southwest with only small seasonal variations in direction. The mean wind direction for the winter months is west-northwest (13% of the time) while southwest winds (12% of the time) predominate during the summer. Mean wind speeds are generally highest during the winter and spring months [10 to 12 miles per hour (mph)], and lower (8 to 9 mph) during the summer months with an average annual velocity of approximately 10 mph.

2.1.4 Shoreline Features

Both shorelines of the Lower Passaic River are almost completely developed, consisting of commercial and industrial properties as well as man-made recreational areas. For the purposes of this document, the shoreline of the Lower Passaic River will be defined as left and right shorelines from the perspective of looking up the river from RM 0.0 toward the Dundee Dam. The thalweg (deepest part of the river channel) of the river is generally in the center of the channel in straight sections and is observed to favor the outside bends of the meanders. The Lower Passaic River encompasses four complete navigational reaches (Point No Point, Harrison, Newark, and Kearny Reaches) and one partial USACE-defined navigational reach (Upstream Reach). The map provided in Plate 1 illustrates the locations of the reaches.

2.1.5 River Miles and Reaches

There have been many studies conducted to date on and along the Lower Passaic River by various entities with different goals. Along with the large amount of data produced came differing, and sometimes conflicting, coordinate systems and references to RMs. In TSI's WP (USEPA, 1995), RM 0.0 was located at the abandoned ConRail Railroad Bridge, which is located approximately 4,000 feet up-estuary from the red channel junction marker at the confluence of the Passaic River and Newark Bay. This RM 0.0 is approximately 4,000 feet up-estuary of the RM 0.0 which has been established for this project. The RM 0.0 established for the LPRRP uses two lighthouses, one located in Essex County, NJ and the other located at Kearny Point in Kearny, NJ, as markers. From these lighthouses an imaginary line was drawn which was assigned as RM 0.0.

Point No Point Reach

The Point No Point Reach extends from the down-estuary river boundary RM 0.0 to approximately RM 2.2 of the Lower Passaic River. The reach follows a north-south trend and is the deepest portion of the Lower Passaic River. Natural inflows to the reach include three small tributaries (Lawyer's Creek, Harrison Creek, and Plum Creek), which enter the reach at RMs 1.8, 1.6, and 0.7, respectively. The reach contains three bridges including the abandoned ConRail Bridge that delineates the lower portion of the Diamond Alkali Passaic River Study Area (PRSA), the Lincoln Highway, and the General Pulaski Skyway Bridges (U.S. Routes l & 9).

The USACE is responsible for delineating and maintaining navigation channels in the Lower Passaic River. The Federal Project Limit was originally adopted in 1907 (modified in 1911, 1912, and 1930) to maintain a channel that is 30 feet deep (relative to MLW) and 300 feet wide in the Point No Point Reach (USEPA, 1995).

The latest available USACE hydrographic survey was performed in 2004 to assess the conditions of the river. Water depths in the Point No Point Reach ranged from -2.0 feet NGVD29 to -23.5 feet NGVD29 (where NGVD29 indicates reference to the National Geodetic Vertical Datum of 1929). The channel in the Point No Point Reach was last dredged in 1983 to the Project Depth of 30 feet. Previous dredging events in the period of interest are reported by IT (1986) in 1940, 1946, 1957, 1965, and 1971; Ianuzzi, *et al.* (2002) reported that dredging occurred in 1884, 1917, 1921, 1922, 1932, 1933, 1941, 1946, 1951, 1953, 1957, 1962, 1965, 1971, 1972, 1977, and 1983.

The shorelines of the reach consist primarily of wooden and stone bulkheads and are bordered by several industrial facilities. The right shoreline contains several large industrial facilities including Western Electric, Badische Anilin- & Soda-Fabrik AG (BASF), SpectraServe, and a former Monsanto manufacturing plant. The left shoreline consists of mostly wooden bulkheads and contains ship piers, several current former chemical and petrochemical manufacturing facilities (including Reichhold Chemical, Sun Oil, and Hoechst-Celanese), and the former Public Service Electric and Gas Company (PSE&G) Essex Generating Station.

Harrison Reach

The Harrison Reach extends from approximately RM 2.2 to RM 4.4 of the Lower Passaic River. Based on the hydrographic survey conducted by USACE in 2004, water depths range from -2.0 feet NGVD29 to -21.9 feet NGVD29. In general, areas of higher deposition are observed on the inside bend of the meanders rather than the outside bends.

Two bridges are located in the Harrison Reach and are positioned close together near the down-estuary end of the reach. Looking up-estuary, the first bridge is a ConRail (Penn Central) Freight Bridge and the second is the bridge for Interstate 95 (New Jersey Turnpike).

The USACE has delineated the Federal Project Limits for the Reach as a 300-foot wide channel with a Project Depth of 20 feet MLW. Dredging in the Harrison Reach was performed in 1949 with a Project Depth of 20 feet. Ianuzzi, *et al.* (2002) reported that dredging occurred in 1884, 1916, 1921, and 1937.

The left shoreline consists primarily of gravel rip-rap and wooden, or stone, bulkheads bordered by a passenger train yard and a train servicing depot. The left shoreline consists of wooden bulkheads bordered by several chemical facilities (*e.g.*, Benjamin Moore, Chemical Waste Management, Hilton-Davis, and inactive industrial properties including Sherwin-Williams, Commercial Solvents, and Diamond Shamrock). An abandoned marina is located at Blanchard Street between the abandoned Commercial Solvents site and the Benjamin Moore facility.

Newark Reach

The Newark Reach extends from approximately RM 4.4 to RM 5.8 of the Lower Passaic River and runs through the downtown section of the City of Newark. This reach begins in an east-west direction and slowly curves in a northerly direction.

The Newark Reach contains numerous bridges. Looking up-estuary, the bridges include: Jackson Street Bridge, Amtrak Railroad Bridge, Harrison Avenue Bridge, ConRail Freight Railroad Bridge, William Stickel Memorial Bridge, and Clay Street

Bridge, which delineates the up-estuary extent of the Newark Reach. The former Center Street Bridge was located between the Amtrak and Harrison Avenue Bridges; however, this bridge has been abandoned and the bridge piers have been removed.

The USACE has designated the Federal Project Limits as 300 feet wide in the Newark Reach with a Project Depth of 20 feet MLW. Dredging in this reach was performed in 1949 to a Project Depth of 16 feet MLW. The last hydrographic survey was performed in 2004 and showed that channel depths in the reach range from -4.5 feet NGVD29 to -22.0 feet NGVD29.

The right shoreline consists of wooden, metal, and stone bulkheads bordered by oil storage tanks, numerous small manufacturing facilities, and a former coal burning facility near the Jackson Street Bridge. The left shoreline consists of parking lots and wooden, or stone, bulkheads bordered by a small park alongside Route 21 (fenced on the river side).

Kearny Reach

The Kearny Reach extends from approximately RM 5.8 to RM 6.8 in the Lower Passaic River. The reach begins in a general north-south direction and then curves to the northeast. The reach contains two bridges: the aforementioned Clay Street Bridge that delineates the boundary between the Newark and Kearny Reaches and a former Erie & Lackawanna Railroad Bridge. The railroad bridge is abandoned in the open position.

The USACE has designated the Federal Project Limits for the Kearny Reach as 300 feet wide with a Project Depth of 20 feet MLW. Dredging in this reach was performed in 1950 to a Project Depth of 16 feet MWL. Ianuzzi, *et al.* (2002) reported that dredging took place in 1913, 1919, 1933, and 1950. Based on the 2004 hydrographic survey, channel depths range from 0.8 feet NGVD29 to -19.2 feet.

The left shoreline consists primarily of stone bulkheads and is bordered by train tracks serviced by ConRail and Route 22 (McCarter Highway) leading northward from downtown Newark. The ConRail train tracks end at the site of the former PPG manufacturing plant located along the left shore of Kearny Reach. The right shore of the Kearny Reach consists of wooden and stone bulkheads bordered by several small manufacturing facilities.

Upstream Reach

The Upstream Reach extends from approximately RM 6.8 to the Dundee Dam. The river direction does not change appreciably in the Upstream Reach. The USACE has delineated the Federal Project Limits as 200 feet wide in the Upstream Reach with a project depth of 16 feet MLW. Dredging in the navigable portion of this reach was performed in 1950 to a Project Depth of 16 feet MLW. Ianuzzi, *et al.* (2002) reported that dredging activities occurred in 1874, 1876, 1878, 1879, 1883, 1899, 1906, 1915, 1916, 1927, 1929, 1930, 1931, 1932, 1934, 1938, 1939, 1940, 1945, 1949, and 1956. Based on the 2004 hydrographic survey, the channel depth range in the reach is 7.9 feet NGVD29 to 11.5 feet NGVD29.

There are 13 bridge crossings over this reach. These are listed along with type, RM, and clearance for each in Table 2-3. To be noted are the low clearance heights of the northernmost fixed bridges; these will pose obstacles to river accessibility for the field team.

Table 2-3: LPRRP Upstream Reach Bridges

RM	Bridge Name	Bridge Type	Vertical Clearance (See Note)
7.8	Conrail Railroad	Swing Bridge	36 ft
8.5	Belleville Turnpike/Route 7	Bascule Bridge	8 ft
10.4	Kingsland Avenue	Swing Bridge	7 ft
11.45	Conrail Railroad	Swing Bridge	26 ft
11.65	Route 3	Bascule Bridge	35 ft
13	Union Avenue	Swing Bridge	13 ft
13.9	Main Street	Fixed Bridge	12 ft
14.45	2nd Street	Fixed Bridge	5 ft
15	8th Street	Fixed Bridge	5 ft
15.75	Passaic Street	Fixed Bridge	5 ft
16	Conrail Railroad	Fixed Bridge	5 ft - 7 ft
16.1	Monroe Street	Fixed Bridge	5 ft - 7 ft
16.35	Van Winkle Avenue	Fixed Bridge	5 ft - 7 ft
17	Outwater Lane	Fixed Bridge	5 ft - 7 ft

* According to NOAA Nautical Charts 12337, 22nd Edition, November 15, 1997.
Note: All vertical clearance figures are given at high tide. The low tide figures would be approximately 5-6 ft more clearance.

The right shoreline of the Upstream Reach consists of wooden and stone bulkheads bordered by several small manufacturing facilities and some private homes at the northern end of the Lower Passaic River. The left shore of the Upstream Reach consists primarily of manufacturing facilities, roadways, and parking lots.

3.0 PRELIMINARY EVALUATION

This section provides a summary of historic data evaluations conducted to date. Preliminary CSMs, developed on the basis of these evaluations, as well as known and potential routes of migration, and known or potential human and environmental receptors, are also presented in this section.

3.1 PRELIMINARY HISTORICAL DATA EVALUATION

An initial historical data evaluation was completed by MPI in May 2004 in which available historical data were evaluated to identify benchmark chemicals. This evaluation focused on surface sediment results; subsurface sediment concentrations were only evaluated within the area where the highest surface concentrations were found. The objectives of the evaluation were to:

- Provide a preliminary quality review of the available data using an established data quality scheme.
- Provide a preliminary review of the available Passaic River sediment data to characterize the nature and extent of sediment contamination and identify a preliminary list of benchmark chemicals. The benchmark chemicals are a subset of the chemicals of potential concern (COPCs) and chemicals of potential ecological concern (COPECs) identified for the project within the PAR (Battelle, 2004a); discussion of COPC and COPEC selection is provided below.

The purpose of identifying benchmark chemicals is to produce a focused list to aid in determining sampling locations for the field investigation. While the benchmark chemicals will be used to establish sampling locations, the list of COPCs and COPECs has been used to establish the analytical list.

The available chemistry data for sediment and fish tissue were evaluated to assess the COPCs for human health and COPECs for ecological receptors as an initial step in the risk assessment process. This screening process and the results are described in detail in the PAR (Battelle, 2004a). In summary, to identify COPCs for consideration in the human health risk assessment (HHRA), the process took into consideration the following factors:

- Is the compound a Class A carcinogen?

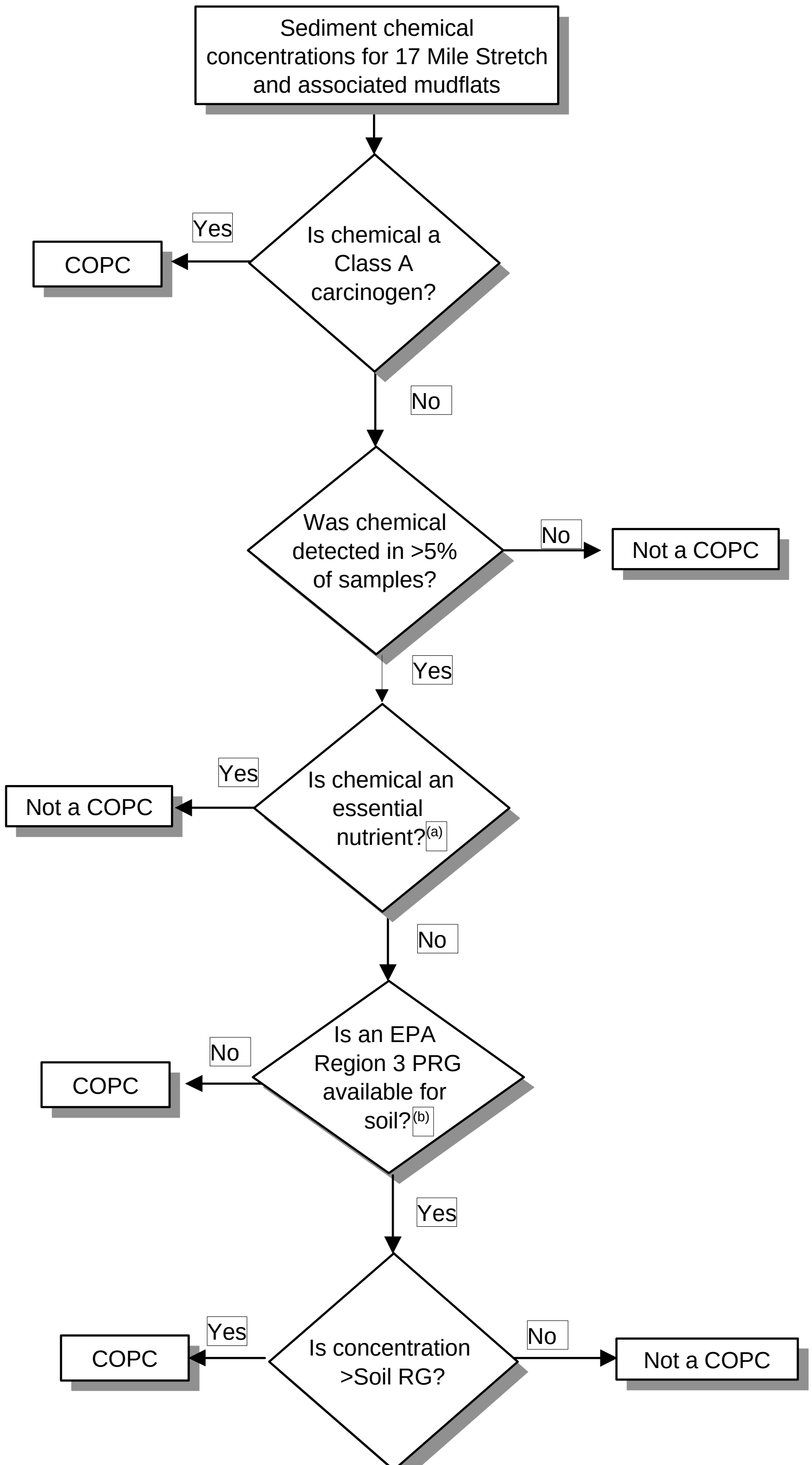
- How frequently is the chemical detected?
- Is the chemical an essential nutrient?
- Does the maximum chemical concentration exceed USEPA Region 9 Preliminary Remediation Goals (PRGs) for soil or USEPA Region 3 Risk-Based Concentrations for fish tissue?

Figure 3-1 provides a decision framework for selecting COPCs on the basis of sediment concentrations for consideration in the HHRA. Figure 3-2 provides a decision framework for selecting COPCs on the basis of tissue concentrations for consideration in the HHRA.

For consideration as COPECs for ecological receptors, the process took into consideration the following factors:

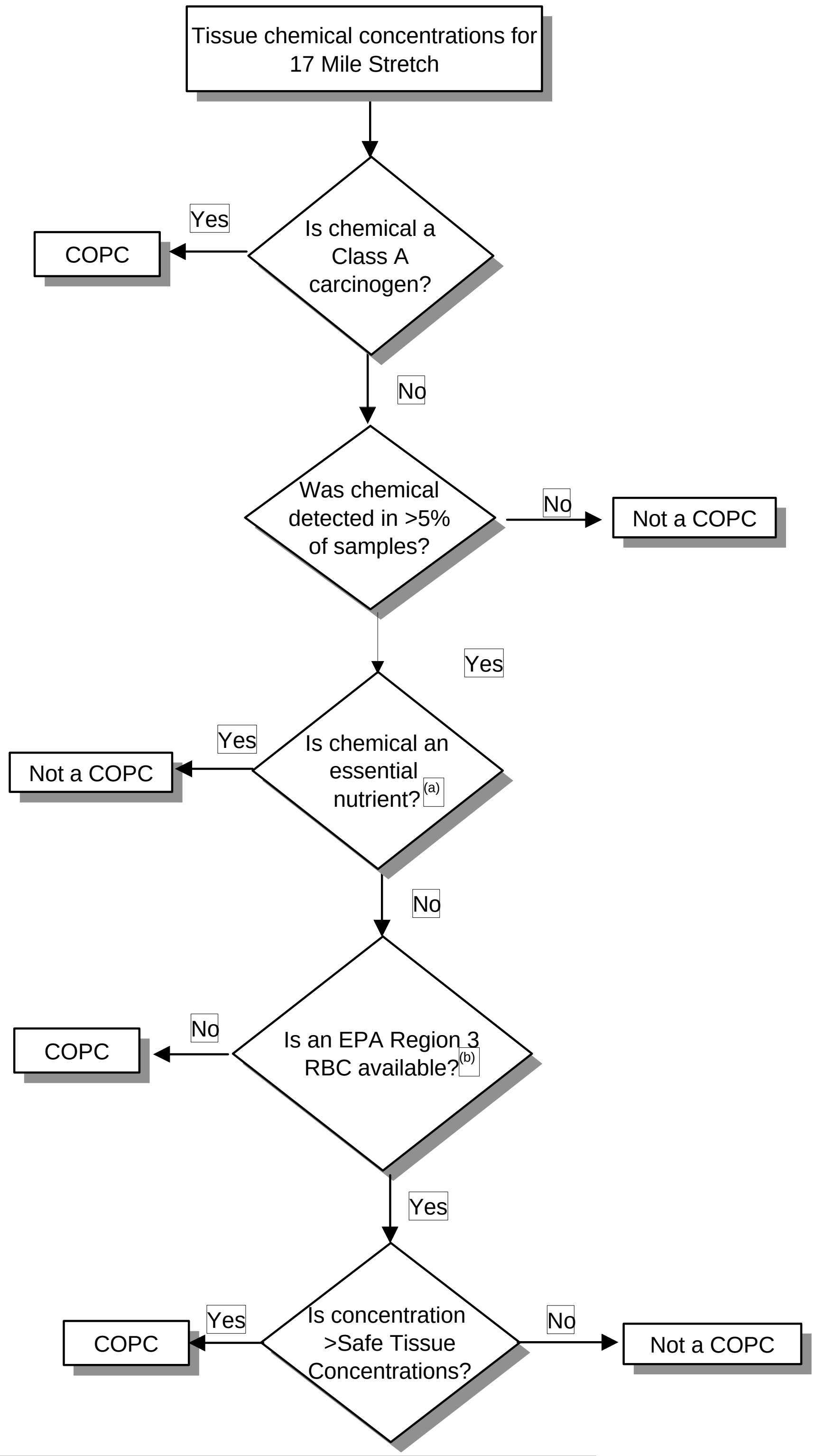
- Is the compound bioaccumulative?
- How frequently is the chemical detected?
- Is the chemical an essential nutrient?
- Does the maximum chemical concentration exceed toxicological benchmarks, such as the Effects Range Low (ER-L), the Effects Range Median (ER-M), or Oak Ridge National Laboratory (ORNL) benchmarks?

Figure 3-3 provides a decision framework for selecting COPCs on the basis of sediment concentrations for consideration in the HHRA.



(a) Essential nutrient with toxicity data will be compared to PRG.
(b) Use of Region 3 PRGs will be based on most current, up-to-date versions.

Figure 3-1: Sediment COPC Decision Diagram for LPRRP HHRA



(a) Essential nutrient with toxicity data will be evaluated based on comparison to PRG.
(b) Use of Region 3 RBC based on most current, up-to-date versions.

Figure 3-2: Tissue COPC Decision Diagram for LPRRP HHRA

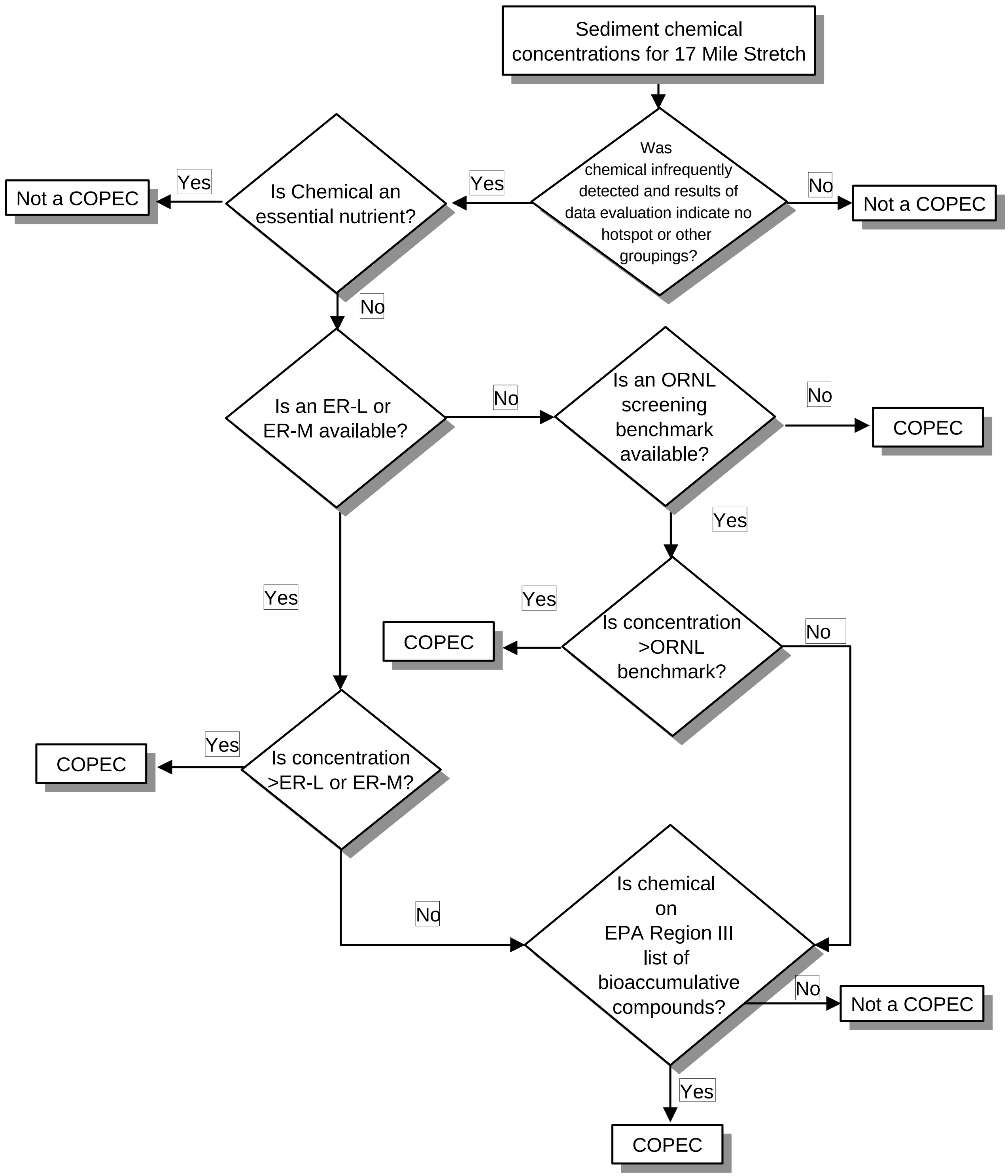


Figure 3-3: Sediment COPEC Decision Diagram for the LPRRP Ecological Health Risk Assessment

The COPCs and COPECs selected through this process are summarized in Table 3-1.

Table 3-1: LPRRP – List of Sediment COPCs and COPECs Identified in PAR

Analyte	Human Health COPC (sediment)	Human Health COPC (fish tissue)	Ecological COPEC
INORGANICS			
Aluminum	✔	✔	
Antimony	✔	✓[a]	✔
Arsenic	✔	✔	✔
Barium	✔	✔	✔
Beryllium			✔
Cadmium	✔	✔	✔
Chromium	✔		✔
Cobalt			✔
Copper	✔	✔	✔
Cyanide	✔		✔
Lead	✔	✔	✔
Manganese	✔	✔	✔
Mercury	✔	✔	✔
Methylmercury		✔	
Nickel	✔	✔	✔
Selenium		✔	✔
Silver	✔	✔	✔
Thallium	✔	✔	✔
Titanium	✔	✔	✔
Vanadium	✔	✔	✔
Zinc		✔	✔
VOCs			
1,2-Dichloroethylene			✔
Benzene	✔		✔
Chlorobenzene			✔
Ethylbenzene			✔
Methyl chloride			✔
Methyl ethyl ketone			✔
Petroleum Hydrocarbons	✔	✔	✔
Vinyl chloride[a]	✓		
SVOCs			
1,2,4-Trichlorobenzene			✓
2,4-Dichlorophenol		✔	
2,4-Dinitrotoluene		✔	
4-Methylphenol		✔	
Biphenyl	✔	✔	✔
bis(2-Ethylhexyl)phthalate	✔		✔
Butyl benzyl phthalate			✔
Carbazole			✔
Dibenzofuran	✔		
Dibenzothiophene	✔	✔	✔

Analyte	Human Health COPC (sediment)	Human Health COPC (fish tissue)	Ecological COPEC
Dibutyltin	✓	✓	✓
di-n-butyl Phthalate	✓		
di-n-octyl Phthalate			✓
Isophorone		✓	
m-Dichlorobenzene		✓	
Monobutyltin	✓	✓	✓
N-nitroso-di-phenylamine			✓
o-Dichlorobenzene		✓	
p-Dichlorobenzene	✓	✓	✓
Tetrabutyltin	✓		✓
Tributyltin	✓	✓	✓
PAHs			
1-Methylnaphthalene	✓	✓	
1-Methylphenanthrene	✓	✓	✓
2-Methylnaphthalene	✓	✓	✓
2,3,5-Trimethylnaphthalene	✓	✓	✓
2,6-Dimethylnaphthalene	✓	✓	✓
Acenaphthene	✓		✓
Acenaphthylene	✓	✓	✓
Anthracene			✓
Benz[a]anthracene	✓	✓	✓
Benzo[a]pyrene	✓	✓	✓
Benzo[b]fluoranthene	✓	✓	✓
Benzo[e]pyrene	✓	✓	✓
Benzo[g,h,i]perylene	✓	✓	✓
Benzo[k]fluoranthene	✓	✓	✓
Chrysene	✓		✓
Dibenz[a,h]anthracene	✓	✓	✓
Fluoranthene	✓		✓
Fluorene			✓
Indeno[1,2,3-c,d]-pyrene	✓	✓	✓
Naphthalene	✓		✓
PAHs, High Molecular Weight (HMW)	✓		✓
PAHs, Low Molecular Weight (LMW)	✓		✓
PAHs, Total	✓		✓
Perylene	✓	✓	✓
Phenanthrene	✓	✓	✓
Pyrene	✓		✓
PCBs			
Total PCBs (Aroclors)	✓	✓	✓
Total PCBs (Congeners)	✓	✓	✓
PESTICIDES/HERBICIDES			
4,4’-DDD	✓	✓	✓
4,4’-DDE		✓	✓
4,4’-DDT	✓	✓	✓
DDTs, Total	✓	✓	✓
Aldrin	✓		✓

Analyte	Human Health COPC (sediment)	Human Health COPC (fish tissue)	Ecological COPEC
Dieldrin	✔		✔
Chlordane		✔	✔
Endrin	✔		✔
Endosulfan			✔
Heptachlor			✔
Heptachlor epoxide			✔
Methoxychlor			✓
Toxaphene			✓
2,4,5-T			✓
2,4,5-TP			✓
2,4-D			✓
2,4-DB			✔
DIOXINS			
2,3,7,8-Tetrachloro-dibenzo-dioxin (TCDD)	✔	✔	✔

[a] Italicized analyte names and "✓" type check-mark indicate that the analyte was not present above the detection limit, but the detection limit was above the screening benchmark/PRG; the maximum concentration is based on ½ the detection limit.

In the initial Historical Data Evaluation, chemical data from 58 relevant studies were examined using the following evaluation methodology:

- Sediment data were divided into surface sediment (less than 0.5 feet depth) and subsurface sediment (below 0.5 feet depth).
- Statistical description of chemicals in surface and subsurface sediments, including the frequency of detection, the frequency of exceedance above applicable screening values, minimum, maximum, and mean concentrations, was performed.
- Sediment concentrations in surface and, if applicable, subsurface sediment were screened against established sediment quality guidelines (SQGs) to determine the exceedance frequency of chemicals. Information on the frequency of exceedance and the frequency of detection were used to determine a preliminary list of benchmark chemicals. In general, the Long, *et al.* (1995) marine/estuarine ER-M screens, which represent a greater than 50% incidence of adverse effects to sensitive species and/or life stages, were selected for screening chemical data. General guidelines of 50% detection frequency where no SQG was given or 25% exceedance frequency when an SQG was available, were used to determine benchmark chemicals. Note that if a chemical group as defined by the SQG is classified as a benchmark chemical, then the individual chemical constituents of the chemical group were assumed to be benchmark chemicals [*e.g.*, total Polychlorinated Biphenyls (PCBs)]. For chemicals for which SQGs were not available, the determination of whether they are benchmark chemicals was based on the overall frequency of sample detection. These guidelines were established to serve as general rules; however, in some instances class-specific criteria were also used where applicable (*e.g.*, since metals are naturally occurring

and ubiquitous in the environment, additional information, such as spatial distribution, was also used in the screening).

- In a case where an SQG is available for an entire chemical group (*e.g.*, Total PCBs), the total concentration of the SQG chemical group was determined by summing the individual constituent concentration with the assumption of zero concentration for non-detected values.

All of the data used in this evaluation were collected at least 4 years ago; the majority of the data were collected prior to 1999. Therefore, these data may not be representative of current surface conditions. To determine how the bottom of the Lower Passaic River has changed with time, a comparison of bathymetric data collected in Fall 2004 by USACE-NY district and bathymetric data collected by USACE-NY district in 1989 was conducted. See Section 3.3.1 Analysis of Bathymetric Change for a summary of the findings. The following subsections provide a summary of geochemical analyses of the historical data and the conclusions derived from this effort.

3.1.1 Data Sources

Electronic historical data have been obtained from the following sources and uploaded to the project database:

- National Oceanic and Atmospheric Administration (NOAA).
- New York State Department of Environmental Conservation (NYSDEC).
- New York State Department of Health (NYSDOH).
- TAMS/EarthTech, Inc (TAMS).
- TSI.
- USACE.
- USEPA.
- USFWS.

As of November 2003, the project database contained 5,857 unique samples collected from 994 locations within the Study Area. These samples, collected from sediment, surface water, and biota, were analyzed for a variety of parameters, which are summarized in Table 3-2. It should be noted that radionuclides were analyzed for purposes of sediment dating, not for the purposes of assessing radiological contamination. The samples were collected during 58 relevant studies; these studies are summarized in Table 3-3.

Table 3-2: LPRRP – Parameters Evaluated in the Initial Historical Data Evaluation

GEOTECHNICAL		
% Clay	% Sand	Dry density
% Course sand	% Silt	Liquid limit
% Fine sand	% Solids	Plastic index
% Gravel	% Fines	Phi angle
% Medium sand	Wet density	Staged unconsolidated undrained triaxial
METALS / INORGANICS		
Aluminum	Cyanide	Silicon
Antimony	Iron	Silver
Arsenic	Lead	Sodium
Barium	Magnesium	Thallium
Beryllium	Manganese	Tin
Cadmium	Mercury	Titanium
Calcium	Nickel	Vanadium
Chromium	Potassium	Zinc
Cobalt	Selenium	Simultaneously extracted metals
Copper		
POLYCYCLIC AROMATIC HYDROCARBONS (PAHs)		
Acenaphthene	Chrysene	Naphthalene
Acenaphthylene	Dibenz[a,h]anthracene	PAHs, Low Molecular Weight
Anthracene	2,6-Dimethylnaphthalene	PAHs, High Molecular Weight
Benz[a]anthracene	Fluoranthene	PAHs, Total
Benzo[a]pyrene	Fluorene	Perylene
Benzo[b]fluoranthene	Indeno[1,2,3-c,d]-pyrene	Phenanthrene
Benzo[e]pyrene	1-Methylnaphthalene	Pyrene
Benzo[g,h,i]perylene	1-Methylphenanthrene	1,6,7-Trimethylnaphthalene
Benzo[k]fluoranthene	2-Methylnaphthalene	2,3,5-Trimethylnaphthalene
Benzoflouranthenes, total		
PESTICIDES		
Aldrin	2,4'-DDT	Endrin ketone
BHC, alpha	4,4'-DDD	Heptachlor
BHC, beta	4,4'-DDE	Heptachlor epoxide
BHC, delta	4,4'-DDT	Isopropalin
BHC, gamma	Total DDT	Kelthane
BHCs, total	Dieldrin	Methoxychlor
Chlordane	Diphenyl disulfide	Mirex
Chlordane, alpha (cis)	Endosulfan sulfate	Nonachlor, cis-
Chlordane, gamma (trans)	Endosulfan, alpha	Nonachlor, trans-
Chlordane, oxy-	Endosulfan, beta	Octachlorostyrene
2,4'-DDD	Endrin	Perthane
2,4'-DDE	Endrin aldehyde	Toxaphene
HERBICIDES		
2,4,5-T	Dalapon	Dinoseb
2,4,5-TP	Dicamba	MCPA
2,4-D	Dichloroprop	MCPP
2,4-DB		
DIOXINS/FURANS		
1,2,3,4,6,7,8-HpCDD	1,2,3,7,8-PeCDF	Total HxCDD
1,2,3,4,6,7,8-HpCDF	2,3,4,6,7,8-HxCDF	Total HxCDF
1,2,3,4,7,8,9-HpCDF	2,3,4,6,7-PeCDF	Total PCDDs
1,2,3,4,7,8-HxCDD	2,3,4,7,8-PeCDF	Total PCDFs
1,2,3,4,7,8-HxCDF	2,3,6,7-TeCDF	Total PeCDD
1,2,3,6,7,8-HxCDD	2,3,7,8-TCDD	Total PeCDF
1,2,3,6,7,8-HxCDF	2,3,7,8-TCDF	Total TCDD
1,2,3,7,8,9-HxCDD	3,4,6,7-TeCDF	Total TCDF
1,2,3,7,8,9-HxCDF	Total HpCDD	Total OCDD
1,2,3,7,8-PeCDD	Total HpCDF	Total OCDF
POLYCHLORINATED BIPHENYLS (PCBs)		

2-Chlorobiphenyl	2,3',5,5'-Tetrachlorobiphenyl	2,3,3',4,4',6-Hexachlorobiphenyl
3-Chlorobiphenyl	2,4,4',5-Tetrachlorobiphenyl	2,3,3',4,5,6-Hexachlorobiphenyl
4-Chlorobiphenyl	2,4,4',6-Tetrachlorobiphenyl	2,3,3',5,5',6-Hexachlorobiphenyl
2,2'-Dichlorobiphenyl	3,3',4,4'-Tetrachlorobiphenyl	2,3',4,4',5,5'-Hexachlorobiphenyl
2,3'-Dichlorobiphenyl	3,4,4',5-Tetrachlorobiphenyl	2,3',4,4',5',6-Hexachlorobiphenyl
2,3-Dichlorobiphenyl	2,2',3,3',4-Pentachlorobiphenyl	3,3',4,4',5,5'-Hexachlorobiphenyl
2,4'-Dichlorobiphenyl	2,2',3,3',5-Pentachlorobiphenyl	2,2',3,3',4,4',5-Heptachlorobiphenyl
2,4-Dichlorobiphenyl	2,2',3,3',6-Pentachlorobiphenyl	2,2',3,3',4,4',6-Heptachlorobiphenyl
2,5-Dichlorobiphenyl	2,2',3,4,4'-Pentachlorobiphenyl	2,2',3,3',4,5,5'-Heptachlorobiphenyl
2,6-Dichlorobiphenyl	2,2',3',4,5-Pentachlorobiphenyl	2,2',3,3',4',5,6-Heptachlorobiphenyl
3,4-Dichlorobiphenyl	2,2',3,4,5'-Pentachlorobiphenyl	2,2',3,3',4,5',6-Heptachlorobiphenyl
4,4'-Dichlorobiphenyl	2,2',3,4,6-Pentachlorobiphenyl	2,2',3,3',4,5,6'-Heptachlorobiphenyl
2,2',3-Trichlorobiphenyl	2,2',3,4',6-Pentachlorobiphenyl	2,2',3,3',4,6,6'-Heptachlorobiphenyl
2,2',4-Trichlorobiphenyl	2,2',3,5,5'-Pentachlorobiphenyl	2,2',3,3',5,5',6-Heptachlorobiphenyl
2,2',5-Trichlorobiphenyl	2,2',3,5',6-Pentachlorobiphenyl	2,2',3,3',5,6,6'-Heptachlorobiphenyl
2,2',6-Trichlorobiphenyl	2,2',3,6,6'-Pentachlorobiphenyl	2,2',3,4,4',5,5'-Heptachlorobiphenyl
2,3,3'-Trichlorobiphenyl	2,2',4,4',5-Pentachlorobiphenyl	2,2',3,4,4',5',6-Heptachlorobiphenyl
2,3,4'-Trichlorobiphenyl	2,2',4,5,5'-Pentachlorobiphenyl	2,2',3,4,4',5,6'-Heptachlorobiphenyl
2,3,4-Trichlorobiphenyl	2,3,3',4,4'-Pentachlorobiphenyl	2,2',3,4,4',6,6'-Heptachlorobiphenyl
2',3,4-Trichlorobiphenyl	2',3,3',4,5-Pentachlorobiphenyl	2,2',3,4,5,5',6-Heptachlorobiphenyl
2,3',4-Trichlorobiphenyl	2,3,3',4',5-Pentachlorobiphenyl	2,2',3,4',5,5',6-Heptachlorobiphenyl
2,3,5-Trichlorobiphenyl	2,3,3',4,6-Pentachlorobiphenyl	2,3,3',4,4',5,5'-Heptachlorobiphenyl
2',3,5-Trichlorobiphenyl	2,3,3',4',6-Pentachlorobiphenyl	2,3,3',4,4',5,6-Heptachlorobiphenyl
2,3',5-Trichlorobiphenyl	2,3,3',5,6-Pentachlorobiphenyl	2,3,3',4,4',5',6-Heptachlorobiphenyl
2,3',6-Trichlorobiphenyl	2,3,4,4',5-Pentachlorobiphenyl	2,3,3',4,5,5',6-Heptachlorobiphenyl
2,4,4'-Trichlorobiphenyl	2',3,4,4',5-Pentachlorobiphenyl	2,3,3',4',5,5',6-Heptachlorobiphenyl
2,4,5-Trichlorobiphenyl	2,3',4,4',5-Pentachlorobiphenyl	2,2',3,3',4,4',5,5'-Octachlorobiphenyl
2,4',5-Trichlorobiphenyl	2,3,4,4',6-Pentachlorobiphenyl	2,2',3,3',4,4',5,6-Octachlorobiphenyl
2,4',6-Trichlorobiphenyl	2,3',4,4',6-Pentachlorobiphenyl	2,2',3,3',4,4',5',6-Octachlorobiphenyl
3,4,4'-Trichlorobiphenyl	3,3',4,4',5-Pentachlorobiphenyl	2,2',3,3',4,4',6,6'-Octachlorobiphenyl
2,2',3,3'-Tetrachlorobiphenyl	2,3,4,5,6-Pentachlorobiphenyl	2,2',3,3',4,5,5',6'-Octachlorobiphenyl
2,2',3,4'-Tetrachlorobiphenyl	2,2',3,3',4,4'-Hexachlorobiphenyl	2,2',3,3',4,5,5',6-Octachlorobiphenyl
2,2',3,4-Tetrachlorobiphenyl	2,2',3,3',4,5'-Hexachlorobiphenyl	2,2',3,3',4,5,6,6'-Octachlorobiphenyl
2,2',3,5'-Tetrachlorobiphenyl	2,2',3,3',4,5-Hexachlorobiphenyl	2,2',3,3',4,5',6,6'-Octachlorobiphenyl
2,2',3,6'-Tetrachlorobiphenyl	2,2',3,3',4,6'-Hexachlorobiphenyl	2,2',3,3',5,5',6,6'-Octachlorobiphenyl
2,2',3,6-Tetrachlorobiphenyl	2,2',3,3',5,6'-Hexachlorobiphenyl	2,2',3,4,4',5,5',6-Octachlorobiphenyl
2,2',4,4'-Tetrachlorobiphenyl	2,2',3,3',5,6-Hexachlorobiphenyl	2,3,3',4,4',5,5',6-Octachlorobiphenyl
2,2',4,5'-Tetrachlorobiphenyl	2,2',3,3',6,6'-Hexachlorobiphenyl	2,2',3,3',4,4',5,5',6-Nonachlorobiphenyl
2,2',4,5-Tetrachlorobiphenyl	2,2',3,4,4',5'-Hexachlorobiphenyl	2,2',3,3',4,4',5,6,6'-Nonachlorobiphenyl
2,2',5,5'-Tetrachlorobiphenyl	2,2',3,4,4',5-Hexachlorobiphenyl	2,2',3,3',4,5,5',6,6'-Nonachlorobiphenyl
2,2',5,6'-Tetrachlorobiphenyl	2,2',3,4,4',6'-Hexachlorobiphenyl	Decachlorobiphenyl
2,2',6,6'-Tetrachlorobiphenyl	2,2',3,4,5,5'-Hexachlorobiphenyl	Aroclor 1016
2,3,3',4'-Tetrachlorobiphenyl	2,2',3,4',5,5'-Hexachlorobiphenyl	Aroclor 1221
2,3,3',5'-Tetrachlorobiphenyl	2,2',3,4,5',6-Hexachlorobiphenyl	Aroclor 1232
2,3,4,4'-Tetrachlorobiphenyl	2,2',3,4',5',6-Hexachlorobiphenyl	Aroclor 1242
2,3',4,4'-Tetrachlorobiphenyl	2,2',3,4,5,6'-Hexachlorobiphenyl	Aroclor 1248
2,3',4,5-Tetrachlorobiphenyl	2,2',3,5,5',6-Hexachlorobiphenyl	Aroclor 1254
2,3',4',5-Tetrachlorobiphenyl	2,2',4,4',5,5'-Hexachlorobiphenyl	Aroclor 1260
2,3',4,6-Tetrachlorobiphenyl	2,3,3',4,4',5'-Hexachlorobiphenyl	Total PCBs
2,3,4',6-Tetrachlorobiphenyl	2,3,3',4,4',5-Hexachlorobiphenyl	
RADIONUCLIDES		
Be-7	Pb-210	Po-210
Cs-137		
SEMIVOLATILE ORGANICS		
Aniline	Dibenzothiophene	Monobutyltin
Azobenzene	Dibutyltin	2-Nitroaniline
Benzidine	1,2-Dichlorobenzene	3-Nitroaniline
Benzo(b)thiophene	1,3-Dichlorobenzene	4-Nitroaniline
Benzoic acid	1,4-Dichlorobenzene	Nitrobenzene
Benzyl alcohol	3,3'-Dichlorobenzidine	2-Nitrophenol
Biphenyl	2,4-Dichlorophenol	4-Nitrophenol
bis(2-Chloroethoxy)methane	Diethyl phthalate	N-nitrosodimethylamine
bis(2-Chloroethyl)ether	Dimethylphthalate	N-nitroso-di-phenylamine
bis(2-Chloroisopropyl)ether	2,4-Dimethylphenol	N-nitroso-di-propylamine
bis(2-Ethylhexyl)phthalate	2,6-/2,7-Dimethylnaphthalene	Pentachloroanisole
4-Bromophenyl phenyl ether	Di-n-butyl phthalate	Pentachlorobenzene
Butylbenzylphthalate	Di-n-octyl phthalate	Pentachloronitrobenzene
Carbazole	4,6-Dinitro-o-cresol	Phenol

4-Chloroaniline	2,4-Dinitrophenol	Pyridine
Chlorobenzilate	2,4-Dinitrotoluene	1,2,3,4-Tetrachlorobenzene
2-Chloronaphthalene	2,6-Dinitrotoluene	1,2,4,5-Tetrachlorobenzene
2-Chlorophenol	Hexachlorobenzene	Tetrabutyltin
4-Chloro-3-methylphenol	Hexachlorobutadiene	Tributyltin
4-Chlorophenyl phenyl ether	Hexachlorocyclopentadiene	1,2,4-Trichlorobenzene
Chlorpyrifos	Hexachloroethane	2,4,5-Trichlorophenol
o-Cresol	Isophorone	2,4,6-Trichlorophenol
Dacthal	4-Methylphenol	Trifluralin
Dibenzofuran	3-Methylphenol/4-methylphenol	TPH
VOLATILE ORGANICS		
Acetone	1,4-Dichloro-2-butene, trans-	Methyl-tert-butyl ether
Acid volatile sulfides	Dichlorodifluoromethane	Methyl ethyl ketone
Acrolein	1,1-Dichloroethane	Methyl iodide
Acrylonitrile	1,2-Dichloroethane	Methyl methacrylate
Allyl chloride	1,1-Dichloroethene	4-Methyl-2-pentanone
Benzene	1,2-Dichloroethylene, cis-	Propionitrile
Bromobenzene	1,2-Dichloroethylene, trans-	N-Propylbenzene
Bromochloromethane	1,2-Dichloroethylene, total	Styrene
Bromoform	1,2-Dichloropropane	1,1,1,2-Tetrachloroethane
BTEX, Total	1,3-Dichloropropane	1,1,2,2-Tetrachloroethane
n-Butylbenzene	1,3-Dichloropropane	Tetrachloroethylene
sec-Butylbenzene	2,2-Dichloropropane	Tetrahydrofuran
tert-Butylbenzene	1,1-Dichloropropene	Toluene
Carbon disulfide	1,3-Dichloropropene, cis-	1,2,3-Trichlorobenzene
Carbon tetrachloride	1,3-Dichloropropene, trans-	1,1,1-Trichloroethane
Chlorobenzene	1,4-Dioxane	1,1,2-Trichloroethane
Chlorodibromomethane	Ethyl methacrylate	Trichloroethylene
Chloroethane	Ethylbenzene	Trichlorofluoromethane
2-Chloroethylvinylether	2-Hexanone	1,2,3-Trichloropropane
Chloroform	Isobutyl alcohol	1,2,4-Trimethylbenzene
Chloroprene	Isopropylbenzene	1,3,5-Trimethylbenzene
2-Chlorotoluene	p-Isopropyltoluene	Vinyl acetate
4-Chlorotoluene	Methacrylonitrile	Vinyl chloride
1,2-Dibromo-3-chloropropane	Methyl bromide	Xylene, m&p
1,2-Dibromoethane	Methyl chloride	Xylene, o-
Dichlorobromomethane	Methylene bromide	Xylenes, total
1,4-Dichloro-2-butene, cis-	Methylene chloride	

Table 3-3: LPRRP – Studies Relevant to the Initial Historical Data Evaluation

PREMIS STUDY ID	ORGANIZATION/ PROGRAM	STUDY NAME
465	NOAA	NOAA NS&T Hudson-Raritan Phase I, 1991
466	NOAA	NOAA NS&T Hudson-Raritan Phase II, 1993
471	NYSDEC	NYSDEC 1975
472	NYSDEC	NYSDEC 1980
473	NYSDEC	NYSDEC 1983
474	NYSDEC	NYSDEC 1984
475	NYSDEC	NYSDEC 1985
476	NYSDEC	NYSDEC 1987
477	NYSDEC	NYSDEC 1990
478	NYSDEC	NYSDEC 1993
479	NYSDEC	NYSDEC 1994
480	NYSDEC	NYSDEC 1995
481	NYSDEC	NYSDEC 1997
482	NYSDEC	NYSDEC 1998
483	TAMS	TAMS Hudson River Database, HR-002
484	TAMS	TAMS Hudson River Database, HR-003
485	TAMS	TAMS Hudson River Database, HR-004
486	TAMS	TAMS Hudson River Database, HR-006

PREMIS STUDY ID	ORGANIZATION/ PROGRAM	STUDY NAME
462	USEPA	EPA EMAP 90-92
463	USEPA	REMAP, 1993
464	USEPA	REMAP, 1994
97	USEPA	PASSAIC 1990 Surficial Sediment Investigation
98	USEPA	PASSAIC 1991 Core Sediment Investigation
99	USEPA	PASSAIC 1992 Core Sediment Investigation
100	USEPA	PASSAIC 1993 Core Sediment Investigation - 01 (March)
104	USEPA	PASSAIC 1993 Core Sediment Investigation - 02 (July)
106	USEPA	PASSAIC 1993 USEPA Surficial Sediment Program
107	USEPA	PASSAIC 1994 USEPA Surficial Sediment Program
119	USEPA	PASSAIC 1995 Biological Sampling Program
120	USEPA	PASSAIC 1995 RI Sampling Program
121	USEPA	PASSAIC 1995 Sediment Grab Sampling Program
122	USEPA	PASSAIC 1995 USACE Minish Park Investigation
144	USEPA	PASSAIC 1996 Newark Bay Reach A Sediment Sampling Program
146	USEPA	PASSAIC 1997 Newark Bay Reach B, C, D Sampling Program
147	USEPA	PASSAIC 1997 Outfall Sampling Program
148	USEPA	PASSAIC 1998 Newark Bay Elizabeth Channel Sampling Program
149	USEPA	PASSAIC 1999/2000 Minish Park Monitoring Program
530	USEPA	PASSAIC 1999 Late Summer/Early Fall ESP Sampling Program
531	USEPA	PASSAIC 1999 Newark Bay Reach ABCD Baseline Sampling Program
532	USEPA	PASSAIC 1999 Sediment Sampling Program
533	USEPA	PASSAIC 2000 Spring ESP Sampling Program
534	USEPA	PASSAIC 2001 Supplemental ESP Biota Sampling Program
535	USACE	93F62MT: MOTBY (MILITARY OCEAN TERMINAL AT BAYONNE)
536	USACE	93F64CL: CLAREMONT 93 REACH III (93FCLMT)
537	USACE	93F64HR: HACKENSACK RIVER
538	USACE	93F64PE: PORT ELIZABETH 93
539	USACE	94F36BU: BUTTERMILK
540	USACE	94F41HU: HUDSON_RIVER
541	USACE	94F62LI: LIBERTY_ISLAND
542	USACE	95F34BR: BAY_RIDGE
543	USACE	95F34RH: RED_HOOK
544	USACE	95F64CL: CLAREMONT_RETEST
545	USACE	95F64PJ: PORT_JERSEY
546	USACE	96PEXXON: EXXON
547	USACE	96PNBCDF: NEWARK BAY CONFINED DISPOSAL FACILITY

PREMIS STUDY ID	ORGANIZATION/ PROGRAM	STUDY NAME
548	USACE	96PPANYNJ: PORT AUTHORITY NEW YORK NEW JERSEY
550	USACE	97F62RH: ACOE_RED_HOOK_FLATS
551	USACE	97F62RH_RE: COE_RED_HOOK_FLATS_RETEST

3.1.2 Data Quality

Prior to conducting the preliminary historical data evaluation, a data quality screening process was devised and used to determine whether or not available historical data were of sufficient quality for inclusion in the project database. A list of 45 attributes (data quality factors) that are the most useful in establishing data quality was compiled into a checklist to determine the quality of data.

Further details regarding the data quality screening process are discussed in the Technical Memorandum: Preliminary Data Quality Scheme – Passaic River Restoration Project Superfund Site (Battelle, 2004b). In summary, the data screening resulted in all 58 relevant studies being assessed as acceptable for this evaluation.

3.1.3 Summary of Results

This section summarizes the major findings of the preliminary Geochemical Historical Data Evaluation for the following classes of chemicals. A list of the parameters selected as benchmark chemicals is included in Table 3-4. Evaluations have not yet been conducted for conventional parameters or total petroleum hydrocarbons (TPH). The primary categories of selected benchmark chemicals include:

- Metals.
- Pesticides/Herbicides.
- Volatile Organic Carbons (VOCs).
- Semi-Volatile Organic Carbons (SVOCs).
- PCBs.
- Dioxins/Furans.

For each chemical class, Table 3-5 summarizes the number of surface and subsurface sediment samples included in the historical data evaluation, the SQGs used, and the benchmark chemicals selected. Refer to Plates 2 through 34, which illustrate the spatial distribution of benchmark chemicals in the sediment. Refer to Tables 3-6 and 3-7 for summaries of the benchmark chemicals.

Table 3-4: LPRRP – Chemicals Identified as Benchmark Chemicals

Benchmark Chemical	Surface Sediment Area of Contamination	Location of Maximum Surface Concentration
METALS		
Lead	RMs 2.0-4.0 (Harrison Reach) and 6.0-7.0 (Kearny Reach)	RM 17 (Upstream Reach)
Mercury	RMs 0.0-7.0 (Point No Point, Harrison, Newark, and Kearny Reaches)	RM 8.7 (Upstream Reach)
Silver	RMs 0.0-7.0 (Point No Point, Harrison, Newark, and Kearny Reaches)	Upstream Reach
Cobalt	RMs 0.0-7.0 (Point No Point, Harrison, Newark, and Kearny Reaches)	Harrison Reach
Zinc	RMs 0.0-7.0 (Point No Point, Harrison, Newark, and Kearny Reaches)	Upstream Reach
PESTICIDES/HERBICIDES		
DDT	RMs 2.0-4.0 (Harrison Reach) and 6.0-7.0 (Newark and Kearny Reaches)	Harrison Reach
Chlordane	RMs 2.0-4.0 (Harrison Reach)	Kearny Reach
Dieldrin	RMs 2.0-4.5 (Harrison Reach)	RM 1.1 (Point No Point Reach)
Mirex	RMs 2.0-4.0 (Harrison Reach)	RM 2.1 (Harrison Reach)
VOCs		
Xylenes	RMs 0.0-6.5 (Point No Point, Harrison, Newark, and Kearny Reaches)	RM 1.2 (Point No Point Reach)
Methyl ethyl ketone	RMs 1.0-6.5 (Point No Point, Harrison, Newark, and Kearny Reaches)	(Not above sediment screening quality guideline)
SVOCs		
HMW PAHs	Between RMs 0.0-7.0 (Point No Point, Harrison, Newark, and Kearny Reaches)	RM 4.5 (Harrison Reach)
LMW PAHs	RMs 0.0-7.0 (Point No Point, Harrison, Newark, and Kearny Reaches)	RM 4.5 (Harrison Reach)
PCBs		
PCBs	RMs 1.0-7.0 (Point No Point, Harrison, Newark, and Kearny Reaches)	Kearny Reach
DIOXINS/FURANS		
2,3,7,8 TCDD and Dioxin/Furan TEQ	RMs 2.5-4.5 (Harrison Reach)	Harrison Reach

Table 3-5: LPRRP – Summary of Samples, Sediment Quality Guidelines, and Benchmark Chemicals Selected

Chemical Class	Number of Samples		Sediment Quality Guidelines Used	Benchmark Chemicals Selected
	Surficial	Subsurface		
Metals	378	643	1998 NJDEP Marine/Estuarine Sediment Screening Guidelines (Long, *et al.* , 1995) ER-M.	Lead; mercury; silver; cobalt; zinc.
Pesticides/ Herbicides	261	626	1998 NJDEP Marine/Estuarine Sediment Screening Guidelines (Long, *et al* ., 1995) ER-M, ER-L.	Total DDT; total chlordane; dieldrin; mirex.
VOCs	142	537	1998 NJDEP Marine/Estuarine Sediment Screening Guidelines (Long, *et al* ., 1995) ER-M, ER-L were not available. Therefore, the most conservative screening values for all other screening guidelines were used (1).	Total xylenes; methyl ethyl ketone.
SVOCs	244 (330 for PAHs)	622 (611 for PAHs)	1998 NJDEP Marine/Estuarine Sediment Screening Guidelines (Long, *et al.* , 1995) ER-M, ER-L were not available for SVOCs. Therefore, the most conservative screening values for all other screening guidelines were used for all other SVOCs (1). For PAHs, the 1997 NOAA Selected Integrative Sediment Quality Benchmarks for Marine and Estuarine Sediments, ER-M values, were used.	High Molecular Weight PAHs; Low Molecular Weight PAHs.
PCBs	255	580	1998 NJDEP Marine/Estuarine Sediment Screening Guidelines (Long, *et al* ., 1995) ER-M.	Total PCBs.
Dioxins/Furans	267	598	1998 NJDEP Marine/Estuarine Sediment Screening Guidelines (Long et al., 1995) ER-M, ER-L were not available. Therefore, a 1 ng TEQ/g (TEQ = Toxic Equivalency Quotient) screening value was used as published by the World Health Organization (1997).	2,3,7,8-TCDD; dioxin TEQ.

(1): These screening criteria include:

- National Ambient Water Quality Criteria (NAWQC): 1997 Sediment Quality Benchmarks, Marine/Estuarine - NAWQC Chronic Values.
- NAWQC: 1997 Sediment Quality Benchmarks, Marine/Estuarine - NAWQC Secondary Chronic Values.
- USEPA Office of Solid Waste and Emergency Response Ecotox Thresholds. As cited in Jones, *et al.*, 1997.
- USEPA Region 5, RCRA Ecological Screening Levels, 2003.
- NOAA: Selected Integrative Sediment Quality Benchmarks for Marine and Estuarine Sediments, ER-M Values, 1997.

Table 3-6: LPRRP – Statistical Report for Benchmark Chemicals in Surface Sediment

Chemical	Min. Conc.	Max. Conc.	Average Conc. (Arithmetic Mean)	Detection Frequency	SQG Conc.	Exceedance Frequency	Units
Lead	< 0.01	2200	252	337 / 344	218	225/344	ppm
Mercury	< 0.01	12.4	3.0	261 / 344	0.71	242/344	ppm
Silver	< 0.01	39.5	4.5	227 / 341	3.7	127/341	ppm
Cobalt	< 0.01	41.1	8.9	299 / 321	NA[1]	NA	ppm
Zinc	< 0.01	1900	425	332 / 344	410	213/344	ppm
Total DDT	6.0	5980	231	238 / 261	46	216/261	ppb
Total Chlordane	3.0	210	49	130 / 232	6.0	126/232	ppb
Dieldrin	3.0	270	27	119 / 261	8.0	110/261	ppb
Mirex	8.0	135	26	12 / 13	7.0	12/13	ppb
Total Xylenes	2.0	440	108	13 / 142	25	9/142	ppb
Methyl ethyl ketone	9.0	83	36	29 / 142	43	9/142	ppb
HMW PAHs (total)	1,500	1,400,000	30,062	326 / 330	9,600	288/330	ppb
LMW PAHs (total)	210	1,410,000	10,603	299 / 330	3,160	158/330	ppb
Total PCBs	230	2,482	1,219	16/16	Not calculated	Not calculated	ppb
2,3,7,8-TCDD	2	13,500	518	260 / 266	NA	NA	ppt

(1): "NA" = None Available

Table 3-7: LPRRP – Statistical Report for Benchmark Chemicals in Subsurface Sediment

Chemical	Min. Conc.	Max. Conc.	Average Conc. (Arithmetic Mean)	Detection Frequency	SQG Conc.	Exceedance Frequency	Units
Lead	1.0	22,000	527	573/619	218	443/619	ppm
Mercury	0.01	29.6	7.7	511/618	0.71	472/618	ppm
Silver	0.63	26.7	9.1	413/616	3.7	363/616	ppm
Cobalt	2.6	42.9	12.8	570/616	NA[1]	NA	ppm
Zinc	10.8	3,110	789	592/619	410	432/619	ppm
Total DDT	4.1	18,600,000[2]	61,250[2]	471/606	46	417/606	ppb
Total Chlordane	3.0	791	72	328/578	6.0	311/578	ppb
Dieldrin	1.3	580	63	313/615	2.0	312/615	ppb
Mirex	No subsurface samples						
Total Xylenes	3.0	150,000	1,130	233/526	25	216/526	ppb
Methyl ethyl ketone	10.0	7,200	109	315/526	43	196/526	ppb
HMW PAHs (total)	220	2,290,000	43,500	517/611	9,600	451/611	ppb
LMW PAHs (total)	280	5,460,000	39,700	474/610	3,160	322/610	ppb
Total PCBs	180	27,560	2,774	351/580	Not calculated	Not calculated	ppb
2,3,7,8-TCDD	0.072	5,300,000	22,000	524/598	NA	NA	ppt

1 – None Available
2 – It should be noted that this sample concentration is anomalous when compared to all of the other Total DDT sample results. Therefore, it is possible that this value is unreliable.

3.1.4 Data Gaps Identified from Initial Historical Data Evaluation

During the surface sediment data evaluation process, the following data gaps were identified:

- There was no current accurate estimation of the amount of sediment deposition to the river. There had been no comparison of historical and current bathymetric data to identify how the bottom of the river has changed over time. This comparison will provide an estimate of the amount of sediment and contamination which has accumulated throughout the past 20 years. In turn, this information provides support for contaminant inventory estimates.
- Data are needed regarding loads coming in from tributaries, point sources, and the Passaic River above the Dundee Dam. These represent external loads to the system that must be compared to the internals loads generated by river sediments.

Understanding internal versus external loadings is essential for forecast simulations (*e.g.*, sediment loading, bioaccumulation, cumulative risks).

- Data are needed to describe the extent of contamination in the upper reaches of the Lower Passaic River. The majority of historical samples were collected from the sediments of the six miles of the Lower Passaic River bordering the Diamond Alkali dioxin manufacturing plant in Newark, NJ. Tidal displacement may serve to carry contaminants upstream with the salt intrusion and eventually contaminate areas upstream of the Harrison Reach.
- Data are needed to better describe the vertical extent of contamination. Knowledge of the vertical extent of contamination is essential to assess impacts of erosion, depth of biological exposure, and potential for groundwater migration of contaminants, as well as the engineering concerns related to any remedial scenarios or restoration opportunities.
- Data are needed to describe mercury geochemistry and in particular, methylmercury formation. Mercury bioaccumulation is generally driven by methylmercury concentrations. Thus, an understanding of mercury geochemistry for the river is important.
- Surface water samples are needed for benchmark chemicals to fully describe conditions in the estuary. Very few historical surface water samples are available for the Lower Passaic River. Surface water samples provide a measure of biological exposure, as well as important geochemical information on contaminant fate and transport and external loads.
- PCB congener data are needed to help identify internal and external loads of PCBs.

These data gaps were considered in the development of DQOs [refer to Section 1.5 of the QAPP – Quality Objectives and Criteria (MPI, 2005a) for further information].

3.2 PRELIMINARY CONCEPTUAL SITE MODEL

The purpose of the CSM is to summarize sources of contaminants, how contaminants enter and are transported within a system, what media are contaminated, and where routes of exposure to organisms and humans occur. As such, the CSM provides an essential framework for assessing risks from contaminants, developing remedial and restoration strategies, determining source control requirements, and determining how to address unacceptable risks. The CSM is a dynamic tool that will be updated and refined continuously during the Study.

Based on the site description and the preliminary historical data evaluation, a CSM was developed for both the ecological (Figure 3-1) and human health (Figure 3-2) assessments. A summary of the information used to derive these CSMs is provided below.

The expansion of industry and subsequent release of chemicals to the Passaic River resulted in high levels of contaminated sediments within the river. Various hazardous substances that have been detected in river sediments include arsenic, cadmium, copper, lead, mercury, nickel, zinc, phthalates, PAHs, PCBs, 4,4'-Dichlorodiphenyltrichloroethane (DDT), petroleum hydrocarbons, dioxins, and pesticides. Some of these contaminants are known to bioaccumulate in tissue and subsequently be transferred up the food chain to upper-trophic organisms, including humans.

Some species of metals, PCBs, PAHs, pesticides (*i.e.*, DDT), and dioxins are known to be hydrophobic, nonpolar contaminants that tend to adsorb tightly to sediment particles. Their transport and fate in the aquatic system is therefore controlled by the movement of the sediment particles. Surface and subsurface sediments can be disturbed by physical processes (*e.g.*, current and wave resuspension, grounding of ship keels and propellers, and liquefaction or slumping), or by biological process (*i.e.*, bioturbation). Sediment accumulation and vertical mixing will control the rate at which these contaminants are being buried and removed from the human and ecological receptor pathways.

Furthermore, a majority of these contaminant classes are known to bioaccumulate within the food chain. Certain metals, PCBs, chlorinated pesticides, and dioxins are all known to bind to tissue and transfer up the food chain. PAHs are not known to bioaccumulate at great rates in tissues; PAH toxicity generally occurs via direct ingestion or inhalation.

The physical characteristics of the system can also impact the movement specifically of metals through the sediments. In anoxic environments, metals such as cadmium, lead, copper, and zinc are typically immobilized as sulfides. These metals can be mobilized via a change in redox potential (*i.e.*, oxidation) and/or drop in pH (although this is unlikely in an estuarine environment). Microbial processes can transform elemental mercury into methylmercury, which is more toxic and bioavailable than the elemental form. In estuaries, methylation tends to occur at higher rates in coastal wetlands and tidal flats under anaerobic conditions.

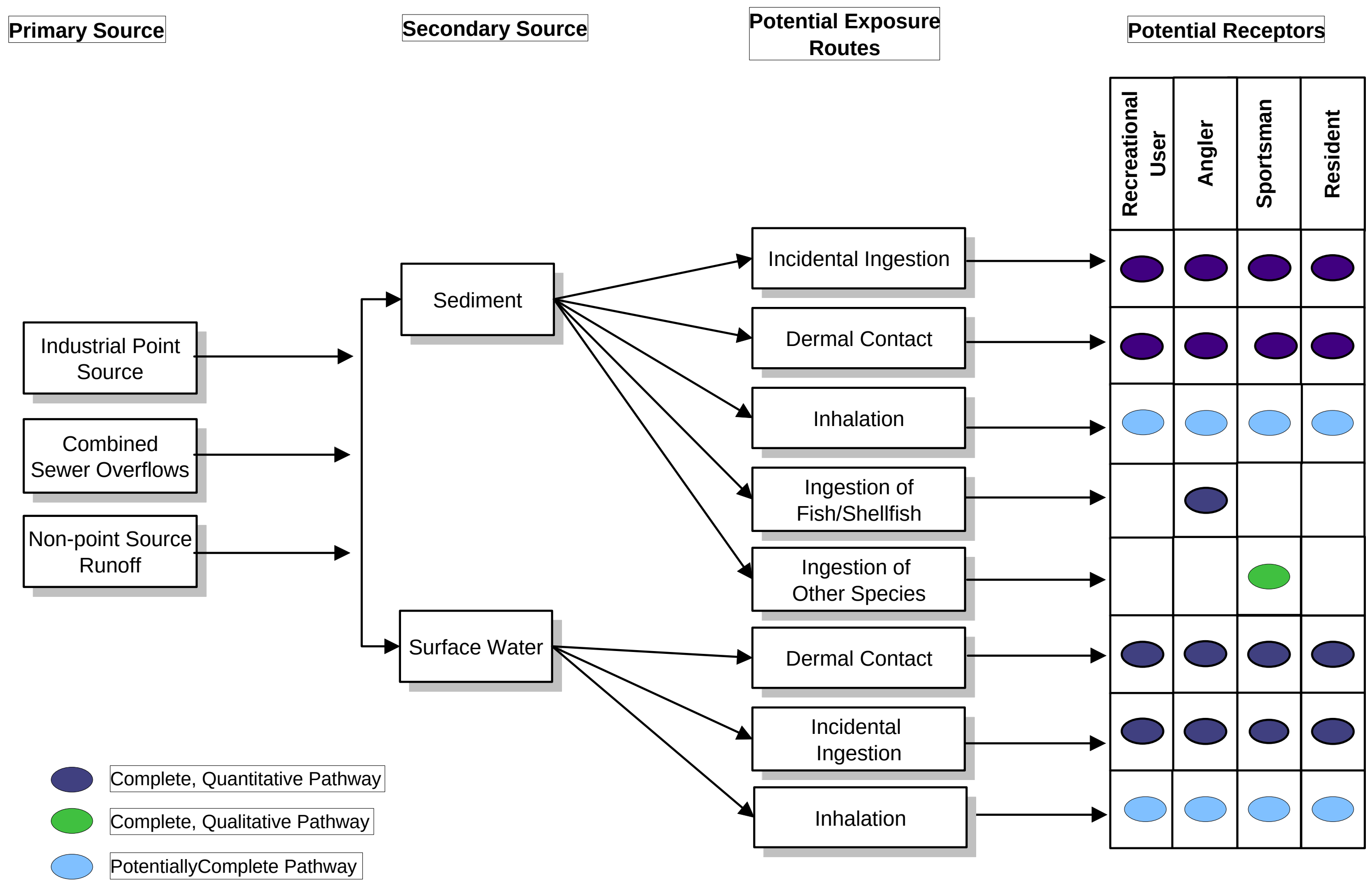


Figure 3-4: LPRRP – Human Health Conceptual Site Model

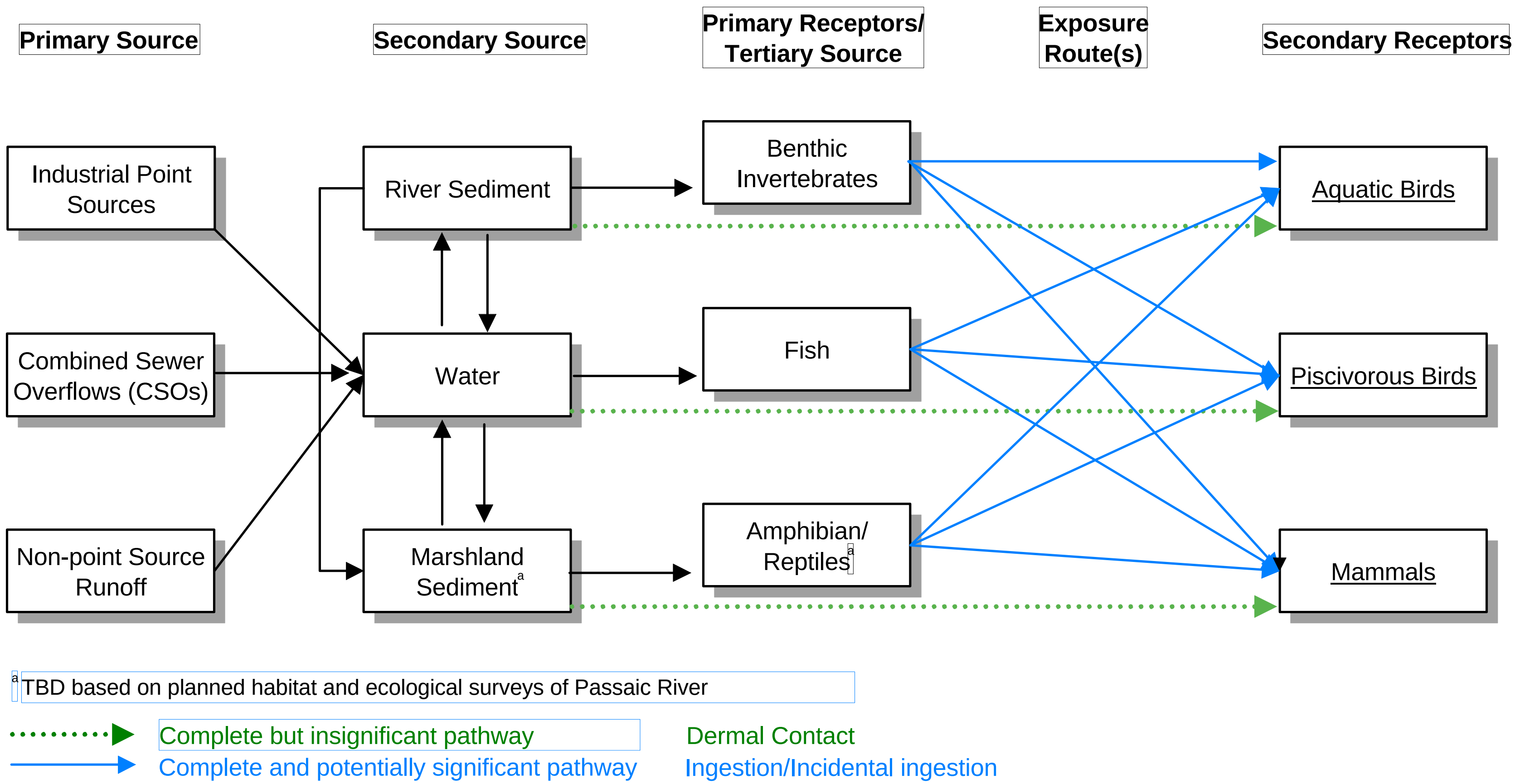


Figure 3-5: LPRRP – Ecological Conceptual Site Model

In contrast, VOCs are somewhat soluble, but volatilization removes them from the water column quickly. Moderate adsorption to sediment occurs where they may accumulate. However, they are susceptible to biodegradation under appropriate physical conditions.

SVOCs present in the water column are susceptible to volatilization. However, they also have a strong propensity to bind to sediments. Once they are bound to the sediment matrix, they are less likely to volatilize in contrast to their presence in the water column. They are susceptible to biodegradation in sediment matrices with ample oxygen content.

Increased urbanization also contributed to extensive habitat loss and degradation which has greatly reduced the functional and structural integrity of ecosystems within the Lower Passaic River. Severe loss of the natural habitat, especially wetlands, for many indigenous and migratory animals has occurred for decades. Since 1940, over 7,500 acres of wetlands have been lost from the lower Passaic River and over 88% of wetlands in the entire Newark Bay area have been eliminated (Iannuzzi, *et al.*, 2002). The few remaining wetlands are small and discontinuous, often measuring only a few feet in width (USACE, 2003). This loss of wetlands has resulted in a decline in bird diversity and fish population. Shorelines covered by bulkheads, rip-rap, structures, and pavement limit the nesting and foraging areas for birds along the river. In addition, tidal creeks and marshes that provide critical habitat to juvenile and migratory fish have been depleted by pollution and loss of habitat, resulting in a decline of fish and shellfish populations along the Passaic River.

With respect to human health, pollution and habitat degradation have limited the recreational and economic use of the river. The State of New Jersey, recognizing the widespread chemical contamination (most notably dioxin) of fish in the Lower Passaic River has prohibited the sale or consumption of all fish and shellfish from this area since the 1980s.

3.3 ONGOING GEOCHEMICAL EVALUATION AND CONCEPTUAL SITE MODEL UPDATE

In addition to the evaluation described above, additional geochemical and sediment stability analysis is being conducted to update the CSM and to provide guidance in determining sampling locations for sediment field programs. These ongoing analyses include: a bathymetric change analysis, sediment geochemistry, spatial distribution of physical properties and contaminant concentrations in sediments, contaminant levels in biota and analysis of hydrodynamic data. A summary of these analyses, including preliminary findings, is discussed below.

3.3.1 Bathymetric Change Analysis

For the historic data evaluation, the bathymetric data sets from 1989 and 2004 were compared to determine the changes in the river bottom over time.

3.3.1.1 Data Sources

1989 Bathymetry Data

The 1989 survey data was originally received as hard-copy mapping. A total of twenty-six sheets were included: one cover sheet and twenty-five sheets with survey points. Sheets 797/2-797/15 covered from the river mouth to approximately RM 7.8, surveyed in Spring 1989. Sheets 798/1-798/11 covered from RMs 7.8 to 15, which were surveyed in Fall 1989. The 1989 survey was conducted for the USACE-New York District by Tallamy, Van Kuren, Gertia, and Associates (TVGA) and was referenced to MLW as defined by the USACE. MPI scanned in the hard copy map sheets and georeferenced them in New Jersey State Plane coordinates (feet NAD83).

2004 Bathymetry Data

Sounding locations and depths were received as Bentley MicroStation Design files (.DGN). The 2004 survey was conducted by Rogers Surveying in the fall of 2004. The 2004 survey was referenced to the NGVD29. The horizontal datum of these data is New Jersey State Plane NAD83 feet.

Vertical Datum Conversion

To complete this comparison, the vertical datum of each bathymetric dataset must be comparable. The difference in datums between the 1989 and 2004 surveys required the selection of a single, standard vertical datum.

NGVD29 is often referred to as Mean Sea Level (MSL). However, the physical MSL changes over time, while NGVD29 is a fixed value. MSL was renamed NGVD in

1973 to remove the reference to “sea level” in the title. For clarity, this WP uses the term NGVD29.

MLW is defined in multiple ways. The USACE defines MLW as a depth below NGVD. NOAA also defines MLW as a value that may change over time; it is the average height of the low waters over the National Tidal Datum Epoch (NTDE). NTDE is measured at gages by NOAA over a 19-year period. NTDE is revised every 20-25 years (see http://co-ops.nos.noaa.gov/datum_update.shtml). Local groups may also define MLW in different ways. When data are referenced to MLW, it is critical to determine which definition of MLW is being used.

NGVD29 was selected as the standard datum to be used throughout the LPRRP for two reasons. First, using NGVD29 avoids any possible future confusion regarding the definition of the datum. Second, by using NGVD29, the bathymetry data are more closely tied to other elevation datasets that will be used in ongoing analyses.

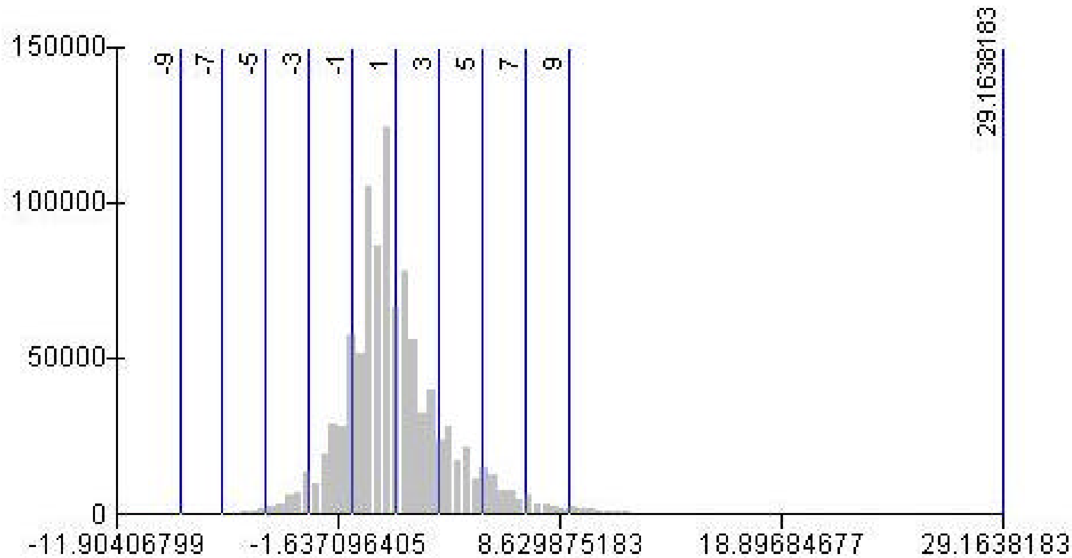
The conversion from MLW to NGVD29 in the Lower Passaic River (from the river mouth to the Dundee Dam) was done by determining the difference between MLW and NGVD29. From the confluence with Newark Bay to approximately RM 6.8, MLW is 2.4 feet below NGVD29. Above RM 6.8, MLW is 2.3 feet below NGVD29. The location where this shift occurs was noted both on the 1989 hard copy map (as a note between map sheets 797/14 and 797/15) and on .DGN files for a 2002 survey of the Passaic River also conducted by TVGA.

All sounding points in the 1989 dataset were assigned a datum correction value of 2.3 or 2.4 based on their location in the Passaic River. The depth, originally referenced to MLW, was converted to the depth according to NGVD29 by subtracting the datum correction value from the original depth.

Change in Bathymetry Over Time

The raster surface for 1989 was subtracted from the raster surface from 2004. This resulted in a change (in feet) from 1989 to 2004.

To display the data, the changes in depth were categorized into intervals. Figure 3-6 shows a distribution where each category represents 2 feet of depth, with the categories on the outer ends capturing those values in the tails less than -9 and greater than 9. The blue lines in the figure represent the limits of each category.



X-axis: Change in depth (feet).
Y-axis: Frequency of occurrence (based on 5-foot grid cells)

Figure 3-6: LPRRP – Equal Interval Categories

Most of the changes in depth are minor to moderate (*i.e.*, between 1-5 feet of change), while a large part of the river exhibits little to no change in depth (*i.e.*, 0-1 foot of change). However, areas with large amounts of deposition are seen and are more common than areas of heavy scour. Please see Plates 36 through 50 for illustrations of each scour/deposition in each one-mile portion of the river.

3.3.2 Sediment Geochemistry

A preliminary geochemical analysis to update the sediment transport CSM and to provide information that can be used to determine sediment core locations, was conducted for the Lower Passaic River using historical sediment data (collected from 1990 to 2000) for the following chemicals: 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD); DDT and its derivatives; PAHs; cesium-137 (Cs-137); and lead-210 (Pb-210). This preliminary sediment CSM provides information on the nature and extent of contamination in the Lower Passaic River and describes the fate and transport of these contaminants and the impacts in the interconnected water bodies.

In general, the preliminary sediment transport CSM concurs with the models proposed by Bopp, *et al*. (1991) and Chaky (2003). Using the geochronology of a sediment core from Newark Bay, Bopp *et al.* (1991) shows that the highest 2,3,7,8-

TCDD concentration occurs in sediment dating to the 1950s and 1960s. This peak 2,3,7,8-TCDD concentration coincides with the peak production and discharge of 2,3,7,8-TCDD into the Passaic River in the 1950s and 1960s. Likewise, the highest DDT concentrations occur in sediment dating from the 1940s and 1950s, coinciding with the manufacturing of this chemical. Hence, in a sediment core, the peak loading of 2,3,7,8-TCDD will occur at shallower depths than the peak loading of DDT, reflecting the changing pattern of industrial production on the Passaic River.

Chaky (2003) adds to this scenario by showing that Newark Bay, which is impacted by the 2,3,7,8-TCDD contamination from the Passaic River, has a ratio of 2,3,7,8-TCDD to total TCDD equal to 0.71. This ratio is distinctly different from other inputs to the Hudson-Raritan Estuary-like atmospheric deposition, upstream sediment transport, and sewage discharge, which have a ratio <0.06. The 2,3,7,8-TCDD to total TCDD ratio that marks Passaic-like polychlorinated dibenzo-p-dioxin (PCDD) contamination can traced throughout the Hudson-Raritan Estuary, suggesting that recent and historical sediments of the New York/New Jersey Harbor appear to be dominated by the Passaic River source.

Observations, conclusions, and the associated analyses and geophysical plots will be documented in greater detail in subsequent technical memoranda and reports.

4.0 WORK PLAN RATIONALE

This Section describes the inputs and basis for the scoping of the data evaluations and field investigations presented in FSP Volume 1 (MPI, 2005b), Volume 2 (in 2006), and Volume 3 (MPI, 2005c), consisting of:

- A summary of the output of the DQO process for the LPRRP.
- A description of the primary "tools" or exhibits included in the WP (MPI, 2005a), FSP Volumes 1 (MPI, 2005b), 2 (in 2006), and 3 (MPI, 2005c), and the QAPP (MPI, 2005a) that are used jointly to design and describe the field investigations and data collection.
- A brief summary of the role of each field investigation in the collection of the data necessary to address the decision statements in the DQOs (Attachment 1.1, QAPP, MPI, 2005a).

4.1 DATA QUALITY OBJECTIVES AND PROBLEM STATEMENT

The historical data evaluations, geochemical evaluations, and field sampling programs described in this WP and Volume 1 (MPI, 2005b), Volume 2 (in 2006), and Volume 3 (MPI, 2005c) are designed to address the problem statement and Fundamental Questions presented in Steps 1 through 2 of the DQOs (Attachment 1.1, MPI, 2005a). The problem statement from DQO Step 1 is summarized below as four primary objectives:

- Prepare the combined CERCLA investigation and WRDA FS report for the LPRRP.
  - What are the contaminants of potential concern (COPCs) and potential ecological concern (COPECs)?
  - What are the quantitative human and ecological health risks posed by the contamination?
  - Are the human health and ecological risks posed by the Study Area unacceptable (*i.e.*, the risks exceed the risk range identified in the National Contingency Plan) and do they warrant assessment of remedial action via a Feasibility Study?
  - What is the comparative performance of the remedial alternatives, based on the CERCLA evaluation criteria?
  - What are the relative risk reductions associated with the various remedial actions in relation to the baseline risks?
- Support a comprehensive, watershed-based plan to restore the functional and structural integrity of the Lower Passaic River ecosystem and to support broader, watershed-wide restoration efforts under WRDA.
  - How should candidate restoration sites be prioritized for ecosystem rehabilitation?

- What is the appropriate restoration plan for suitable candidate sites?
- What are the viable alternatives to reduce contaminant loading in the Harbor and improve dredged material management for the navigational dredging program?
- What other WRDA projects are appropriate, feasible, and cost-effective?

- Support development of a natural resource damage assessment (NRDA) under CERCLA to provide restoration for natural restoration for natural resources injured by contamination and to compensate for the public's lost use of those resources.
  - Which of the public's natural resources are injured by the contaminants discharged by the responsible parties, and how much is injured?
  - What is the pathway of the contaminants from their release to the injured resources?
  - What is the appropriate type and amount of restoration needed to restore injured resources and compensate the public for their lost use?

The problem statement is modified by the following Fundamental Questions developed to guide the investigation:

1. If we take no action on the River, when will the COPCs and COPECs recover to acceptable concentrations?[1]
2. What actions can we take on the River to significantly shorten the time required to achieve acceptable or interim risk-based concentrations for human receptors and ecological receptors?
3. Are there contaminated sediments now buried that are likely to become "reactivated" following a major flood, possibly resulting in an increase in contaminants within the fish/crab populations?
4. What actions can we take on the River to significantly improve the functionality of the Lower Passaic River watershed?[2]
5. If the human and ecological risk assessments for Newark Bay demonstrate unacceptable risks due to export of contaminants from the Passaic River, will the plan proposed to achieve acceptable risks for Passaic River receptors significantly shorten the time required to achieve acceptable or interim risk-based concentrations for human and ecological receptors in Newark Bay, or will additional actions be required on the Passaic River?[3]
6. What actions can we take on the River to significantly reduce the cost of dredged material management for the navigational dredging program?

1: With "acceptable" as a determination of whether COPCs pose unreasonable risk to human health (based on cancer risks between 1E-06 and 1E-04, and noncarcinogenic health effects based on a hazard index greater than 1), and whether COPECs pose unreasonable risk to ecological health (based on an ecological risk hazard index greater than 1).
2: With "significantly" requiring policy input.
3: Note that this question is a shared one with the RI/FS for the Newark Bay Operable Unit since the actual benefits of such reduction will need to be jointly determined; DQOs lay out the appropriate limits of investigation for the Study Area.

4.2 DATA EVALUATION AND FIELD SAMPLING PLAN DESIGN

Four primary "tools" or exhibits were employed to design the historic data evaluations and field sampling programs are listed below:

- The DQOs (QAPP Attachment 1.1, MPI 2005a), which enumerate the decision statements and data inputs required to accomplish the investigation.
- The CSM, which identifies the sources and mechanisms of potential contaminant release within the Lower Passaic River and the possible pathways whereby human and ecological receptors may be exposed to sediment contaminants (refer to Section 3.3 – Ongoing Geochemical Evaluation and Conceptual Site Model Update, of this WP).
- The Data Needs/Data Uses table (QAPP Attachment 1.2, MPI, 2005a), which summarizes the initial data needs by environmental media, analytical parameters, and approximate sample quantities. The data needs presented in the current version of the table are a subset of the data inputs set forth in the DQOs (*e.g.*, biota sampling will not be addressed until FSP Volume 2 is prepared).
- A Dynamic WP approach, summarized by decision strategy figures in FSP Volume 1, Figures 3-19 through 3-24 (MPI, 2005b) that present both field and management decisions integral to the adaptive execution of a field sampling program that will provide data inputs for the critical project decisions.

The DQOs and the CSM provide a basis for the design of the field investigation, outlining, respectively, the necessary decision statements/data inputs and the hypotheses regarding the environmental fate of the contaminants that direct the focus of the field programs. The Data Needs/Date Uses table sets forth the initial scoping of the field programs based on the DQOs and current CSM. The decision trees allow for adaptive modifications to the field sampling programs, understanding that each new piece of data obtained from the field investigations, and the progress of the geochemical evaluation, has the potential to modify the CSM and require adjustment to the investigation scope.

4.3 FIELD INVESTIGATIONS AND DATA NEEDS

As presented in the QAPP (Attachment 1.1, MPI, 2005a), the following major inputs are required to answer the CERCLA investigation and WRDA study questions identified in Section 4.1 – DQOs and Problem Statement:

1. A hydrodynamic, hydrological, and biological model of the Study Area to facilitate evaluation of sediment and water column contaminant fate and transport.

2. Physical, hydraulic, hydrologic, hydrodynamic, and biological data to calibrate and validate the model of the Study Area.
3. Sediment and water column analytical data to establish the nature and extent of contamination.
4. Exposure assessment data to complete the human and ecological health risk assessments.
5. Physical and chemical data necessary for evaluation of remedial alternative performance in the Study Area (*e.g.*, debris survey and sediment geotechnical data required for dredging feasibility evaluation).
6. Remedial alternative performance data (*e.g.*, unit costs, short-term effectiveness, long-term effectiveness, implementability) to facilitate the comparative evaluation of alternatives for the FS.
7. Characterization of physical and chemical properties of environmental media at candidate restoration sites to evaluate the feasibility of WRDA restoration efforts.
8. Ancillary elements to facilitate data acquisition, presentation and analysis, such as site mapping, Geographical Information System (GIS), and PREmis project database.

As summarized in the Data Needs/Data Uses Table, (Attachment 1.2, MPI, 2005a), each field investigation has a role in obtaining the data necessary to address the DQOs and the Data Needs. A brief summary organized by field program is provided below:

- <u>Geophysical Survey</u>. The side scan sonar (SSS) and sub-bottom profiling surveys planned for Spring 2005 will yield surficial sediment texture and subsurface stratigraphic data that can be used to update the CSM, plan the High Resolution and Low Resolution Sediment Coring Programs, calibrate the Hydrodynamic and Sediment Transport Models, and evaluate restoration options. The “ground truth” sediment sampling program necessary to interpret the geophysical survey data will also provide geotechnical sediment data needed by the modelers and by the engineers evaluating the feasibility of various remedial and restoration alternatives.
- <u>High Resolution Sediment Coring Program</u>. The dated cores are necessary to update the CSM, plan the Low Resolution Sediment Coring Program (including analytical parameter selection), and calibrate/validate the Sediment Transport Model.
- <u>Low Resolution Sediment Coring Program</u>. The low resolution sediment cores are necessary to evaluate the spatial extent of sediment contamination from a remedial and restoration alternative evaluation/selection perspective. This “workhorse” sediment coring program will also provide the majority of the sediment contaminant concentration and physical properties data necessary for the human health and ecological risk assessments, Sediment Transport Model calibration/validation, and the Fate and Transport Model calibration/validation.

- Mudflat Sediment Coring Program. This program is a subset of the Low Resolution Sediment Coring Program, with a special emphasis on human health and ecological risk assessment. The program also has a function in the assessment of spatial extent of contamination from a remedial and restoration feasibility perspective and in evaluating restoration options.
- Porewater Sampling Program. This program will be developed to calibrate/validate the contaminant Fate and Transport Model and support the ecological risk assessment.
- Fixed Transect Water Column Sampling Program. This program will create a robust water quality data set from the Lower Passaic River that will be used to update the CSM and to calibrate/validate the Hydrodynamic, Sediment Transport, and Fate and Transport Models.
- Tributary Water Column Sampling Program. This program is a subset of the Fixed Transect Water Column Sampling Program that addresses the data need for information on contaminant loads at the Passaic River modeling boundaries and evaluate potential for recontamination of remedial and restoration options.
- Rising/Falling Tide Sampling Program. This program is intended to explore chemical concentration gradients in the water column as potential indicators of contaminated sediment zones, CSOs, and other discharges. The details of this program are not fully scoped and will be addressed for the 2006 sampling season.
- Candidate Restoration Sites. This program is intended to investigate WRDA restoration sites for potential environmental contamination and to gather site physical features data necessary for restoration design.
- Environmental Dredging and Sediment Decontamination Technology Pilots: These pilots are intended to gather site-specific data on dredging productivity and sediment resuspension as input to the FS evaluation of remedial and restoration alternatives. They are also intended to test whether Passaic River sediment can be treated to produce economically viable beneficial end use products.

5.0 FIELD INVESTIGATION TASKS

5.1 OVERVIEW

This section summarizes field investigation tasks required to support the data needs of the CERCLA and WRDA programs. Figure 5-1 provides an example overall decision strategy identifying major components of the field sampling program, sources of input, and the interactive nature of these components.

More detailed information regarding the field tasks can be found in the FSP Volume 1 (MPI, 2005b), Volume 2 (in 2006), and Volume 3 (MPI, 2005c) for the LPRRP, as described in Section 1.2. Additional information regarding quality assurance/quality control (QA/QC) procedures for these sampling events can be found in the QAPP (MPI, 2005a). Each task is linked to the appropriate section of the PMP (USACE, *et al.*, 2003), which is the initial planning document for the LPRRP.

5.2 BATHYMETRIC AND GEOPHYSICAL SURVEYS (PMP TASKS JAA, JDE)

The following subsections describe the objectives and approaches for bathymetric and geophysical surveys.

5.2.1 Base Maps and Bathymetric, Aerial, and Supplemental Land Surveys

The objectives of the bathymetric and aerial surveys are to obtain recent, detailed geographic data and to develop mapping of the Passaic River bathymetry and shoreline to address the following data needs:

- Evaluate the river's configuration and geomorphology and compare these characteristics to historical data.
- Identify potential sediment scour/deposition areas in the Passaic River.
- Support feasibility analyses and evaluation of remedial and restoration alternatives.
- Determine the elevation and topography of candidate sites to support restoration design.

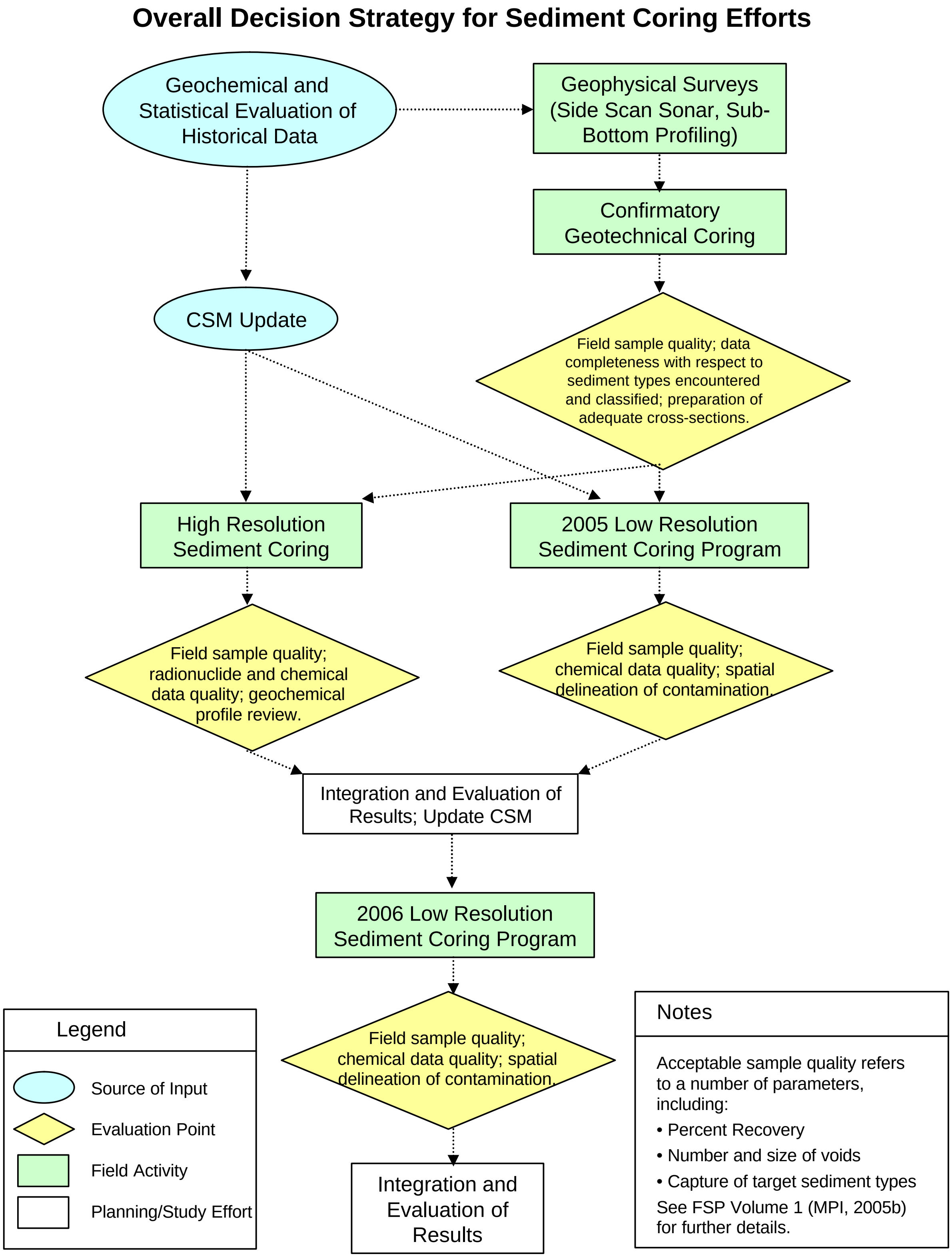


Figure 5-1: LPRRP – Example Overall Decision Strategy

- Determine the grades of the side slopes of the Passaic River and tributaries to support design of bank stabilization/re-grading measures that may be necessary during restoration.
- Develop hydraulic analyses, which will aid in the design of the re-grading plan.
- Determine site access and locations of utilities and other objects.
- Delineate in-river habitats, including in-channel, near-shore, mudflat, and submerged aquatic vegetation beds.

5.2.1.1 Bathymetric Surveys

In 2004, the USACE conducted a bathymetric survey of the LPRRP. These bathymetric and shoreline data cover the 17-mile stretch of the Lower Passaic River. Based on the data collected, mapping of the Passaic River bathymetry and shoreline will be developed in support of the data needs as presented above.

5.2.1.2 Aerial Surveys

To survey outside the channel of the Passaic River and upland adjacent areas, Digital Ortho Photography (aerials) will be obtained. The photography will be collected with enough accuracy to produce 0.5-foot contours on one inch equals thirty feet (1? = 30') scaled maps. Data collected will be integrated with data collected from bathymetric surveys to create bathymetric and shoreline maps of the 17-mile stretch of the Lower Passaic River.

5.2.1.3 Land Surveys

Land surveys will be conducted in order to obtain data, develop mapping, and understand constraints for portions of candidate restoration sites not already addressed by existing data and the bathymetry/aerial surveys.

5.2.2 Geophysical Surveying

The purpose of the geophysical survey is to aid in the interpolation between sediment core sampling locations to reduce uncertainty regarding sediment texture and profile, and potentially, contaminant concentrations, to support engineering decisions required for the FS. The objectives for the geophysical surveys include:

- Assess the texture of the surficial sediment to understand the characteristics of the Passaic River bottom, characterize existing benthic habitat and invertebrate communities, and provide input to evaluating the feasibility of restoration activities (*e.g.*, wetland rehabilitation or benthic habitat restoration) and remedial actions (*e.g.*, capping, dredging) at various locations along the river.
- Estimate the amount/extent of debris and other targets (*e.g.*, utilities, wrecks) in the Lower Passaic River to evaluate the feasibility of remedial activities (*e.g.*, dredging, capping) and achieving restoration objectives at a particular site.
- Identify the sediment types and depths of stratigraphic layers to evaluate the locations and lengths of sediment cores that will be collected for chemical and physical analysis to support field investigation design and support engineering analyses.
- Develop interpretive diagrams of chronological sediment layering in the river bed. This will be a critical input in estimating whether highly contaminated sediments in the Lower Passaic River are stable or may be transported into Newark Bay. Identify the significant stratigraphic/depositional layers of the sediment to support investigations and engineering analyses.

The geophysical survey will consist primarily of an SSS survey to characterize and map sediment texture in the Passaic River. Sub-bottom profiling will be implemented as a supplement to the SSS survey. The extent of the sub-bottom profiling effort will depend on its success in penetrating the river bottom as demonstrated in a geophysical prove-out survey (*e.g.*, if methane gas is present in high quantities, then additional effort may not prove to be worthwhile).

SSS provides mosaic images of the investigation area while sub-bottom profiling investigates sediment stratigraphy and refines the geologic framework between coring locations. Resolution is expected to be approximately one square foot/pixel or finer. Acoustical techniques will be used to derive interpretive diagrams of the river bed, and to identify sediment characteristics of the river bed and active sedimentation processes; ground penetrating radar, supplemented by sampling, may be used as well. Confirmatory shallow sediment core and deep sediment core sampling of river bottom sediments will be conducted to calibrate and verify the results of the geophysical investigation and provide geotechnical information for the sediments.

These data will be used to delineate areas of fine- and coarse-grained sediments, areas of sedimentary bedforms indicative of potential sediment erosion and deposition, and benthic habitat. These data will also be used as a guide for placement of additional sediment cores to delineate the extent of contamination, and in characterizing aquatic habitats.

5.3 SEDIMENT INVESTIGATIONS (PMP TASKS JAC, JFB)

Several different types of sediment samples will be collected during the LPRRP investigation. Each type of sample is described below.

5.3.1 Confirmatory Geotechnical Coring for Geophysical Surveys

The initial geotechnical sediment sample collection efforts are expected to consist of the collection of confirmatory "ground truth" samples to support the SSS and sub-bottom profiling geophysical surveys described in FSP Volume 3 (MPI, 2005c) and summarized in Section 5.2.2 – Geophysical Surveying of this WP. If appropriate, finely segmented, near-surface (approximately 1-2 feet in depth) push cores will be collected during the SSS confirmatory sampling effort to satisfy sediment transport modeling needs. It is important to note that the ground truth sampling required for the sub-bottom profiling will consist of the collection of deep cores. If sub-bottom profiling is unable to generate usable data, a deep geotechnical coring program will be conducted anyway, and is initially planned to consist of the collection of one core every 0.5 mile along the Lower Passaic River for a total of 35 cores. Geotechnical data will be collected to address the following project data needs:

- Identify physical features (*e.g.*, sediment type and stratigraphy) of the Lower Passaic River [refer to Data Quality Objective (DQO) Subtopic No. 4 in QAPP Attachment 1.1 (MPI, 2005a)].
- Support of Geophysical Survey activities [refer to DQO Input No. 4e in QAPP Attachment 1.1 (MPI, 2005a)].
- Characterize sediment transport in the Lower Passaic River to support model development [refer to DQO Subtopic No. 3 in QAPP Attachment 1.1 (MPI, 2005a)].
- Select locations for high resolution sediment cores, low resolution sediment cores, and sediment erodability experiments [refer to DQO Input No. 8h in QAPP Attachment 1.1 (MPI, 2005a)].
- Identify physical properties of sediments for evaluation of remedial and restoration alternatives [refer to DQO Subtopic No. 22 in QAPP Attachment 1.1 (MPI, 2005a)].
- Determine sediment characteristics to support evaluation of benthic habitat and restoration opportunities [refer to DQO Subtopic No. 28 in QAPP Attachment 1.1 (MPI, 2005a)]. It is important to note that much of this data will be collected under FSP Volume 3 (MPI, 2005c).

The cores will be advanced using vibracoring methods and small diameter (1-2 inch) core tubes to expedite collection and minimize IDW generation. The cores will be advanced until refusal or pre-disturbance sediments are encountered, so that each potentially contaminated stratum can be visually classified, (*i.e.*, using ASTM and unified soil classification system soil descriptions), and tested in the field, (*e.g.*, using pocket penetrometer, vane shear, or other instruments).

The cores will not be segmented, but will simply be split open longitudinally and described in continuous, 2-foot intervals. Record samples will be retained at the discretion of the field engineer in 6 ounce (oz.) glass jars. Selected sediment samples will be submitted for physical properties analysis via off-site laboratory. If the sub-bottom profiling survey generates adequate quality stratigraphic descriptions (refer to DQO Subtopic No. 4 and “prove-out” survey in QAPP Attachment 1.1, MPI, 2005a), the need for a separate geotechnical coring program will likely be obviated. Further details regarding the geotechnical coring program are provided in Section 3.1 – Task 1 – Geotechnical Sediment Analyses, of FSP Volume 1 (MPI, 2005b).

5.3.2 High Resolution Sediment Coring

The High Resolution Sediment Coring Program will examine long term trends in COPC/COPEC transport and fate via an examination of the sediment record. The specific issues to be addressed in this study include:

- Recent trends in COPC/COPEC concentrations in sediments and, by implication, recent trends in mean annual water column COPC/COPEC concentrations.
- Nature and vertical extent of current sources of COPCs/COPECs to the Lower Passaic River.
- Nature and vertical extent of historic input of COPCs/COPECs to the Lower Passaic River.
- Rate of in situ chemical degradation in the Lower Passaic River sediments.
- Anticipated residence time for COPCs/COPECs in the sediments.
- Geochemical processes affecting sediment COPC/COPEC levels, as well as fate and transport and bioavailability of COPCs/COPECs.
- Burial rate and age progression with depth of sediment using long-lived radionuclides.
- Depth of the mixing zone using short-lived radionuclides.

Up to 8 high resolution cores will be initially collected from areas of relatively continuous fine-grained sediment material in the Lower Passaic River, and each core will be 15 to 40 feet in length (3 cores in the Lower 6 miles, 4 cores in the Upper 11 miles, and 1 core up-estuary of the Dundee Dam). Due to the proposed core length, some cores will have to be collected by advancing casing into the sediment and collecting sample with a continuously advanced 5-foot long split spoon.

Each high resolution core will be generally segmented into 12 cm (4.72 in) slices, based on current assumptions regarding sediment deposition rates. However, the top segment may be segmented into finer slices, based on the deposition rates estimated for various areas through the ongoing geochemical evaluation. Each sample will be analyzed for radionuclide dating, and selected samples will subsequently be analyzed for PCB congeners, DDT and metabolites, dioxins, and metals. The 2005 High Resolution Coring Program will generate up to 546 samples for analysis.

An additional two or more high resolution cores may be required during the 2006 field sampling season to complete the investigation of the sediment contaminant depositional chronology.

The cores collected for this program will be interpreted as records of water-borne COPC/COPEC transport. Core X-rays may be considered based on further evaluation of existing data and geophysical survey results.

Based on the fine resolution of sediment cores (*i.e.*, 2 cm, 3, cm, 5 cm, 20 cm) required for hydrodynamic/risk assessment modeling needs, samples collected from a single core for analysis are likely to be of insufficient size (*e.g.*, volume, mass) to meet analytical laboratory requirements for minimum sample size, possibly affecting reporting limits. Possible solutions can include reducing the number of analytes requested, co-locating cores to obtain sufficient sample volume, modification of equipment to obtain larger sample volume, or reaching agreement with USEPA and analytical laboratories to accept smaller sample volumes than specified in standard methods. None of these approaches is without problems or will satisfy every situation; it will be necessary to establish a decision framework collaboratively among USEPA Contract Laboratory Program (CLP) chemists and project team members.

5.3.3 Low Resolution Sediment Coring

A low resolution sediment coring investigation will be conducted within the Lower Passaic River. The objectives for the Low Resolution Sediment Coring Program include:

- Delineation of the horizontal and vertical extent of sediment COPC/COPEC concentrations within the Lower Passaic River; obtain chemical data for risk assessment preparation.
- Investigation of previously unknown or poorly documented areas of sediment COPC/COPEC contamination, especially in the upper 11 miles of the Lower Passaic River and tributaries where little or no historical sampling has occurred.
- Estimation of the physical properties of the sediments within the Lower Passaic River.
- Modeling of bioturbation and support calibration and validation of the hydrodynamic and sediment transport model and the fate and transport model.

In the lower 6 miles of the Lower Passaic River (Diamond Alkali Operable Unit 2), 15 co-located cores will be collected to confirm the utility of the 1995 TSI data set. Co-located cores will be positioned to:

- Target varying contaminant concentrations in the historic data set (from the lower to the upper limits of the detected ranges).
- Explore various spatial characteristics of the known contaminant nature and extent (centers of known "hotspot" areas and fringes of contaminated areas).
- Investigate both incomplete (depth extent of contamination not documented) and complete historic coring locations.

In the upper 11 miles of the Lower Passaic River, initial low resolution cores will be installed at a density equivalent to transects located 1 mile apart, with 3 cores on each transect. This initial transect spacing was chosen due to the reduced amount of historic subsurface sediment data available for this area.

Low resolution sediment coring samples will be collected via vibracoring, push coring, or piston coring, as necessary to obtain adequate recovery and retrieve representative sediment samples. The type of coring technique used will initially be selected based on the physical characteristics of the sediments. This may be field-corrected based on actual conditions encountered.

Each low resolution core will be segmented into 2-foot long samples and the applicable sections will be analyzed for a variety of chemical and physical parameters. The cores will generally be segmented into two foot intervals, although the segmentation scheme for every third core will include 0-2 cm, 2-5 cm, 5-10 cm, and 10-30 cm near-surface aliquots to generate data for use in the Sediment Transport Model. Further information regarding core locations, spacing, and target depth is provided in FSP Volume 1 (MPI, 2005b); these factors will be determined and modified accordingly based on geochemical data analysis of existing core data, geophysical surveys, and field conditions. Modeling of bioturbation is needed to assess two variables: the rate of mixing (important for diagenetic studies of sediment), and the maximum depth of mixing (important for assessing the historic sediment records).

Based on the fine resolution of sediment cores (*i.e.*, 2 cm, 3, cm, 5 cm, 20 cm) required for hydrodynamic/risk assessment modeling needs, samples collected for analysis are likely to be of insufficient size (*e.g.*, volume, mass) to meet analytical laboratory requirements for minimum sample size, possibly affecting reporting limits. Possible solutions can include reducing the number of analytes requested, co-locating cores to obtain sufficient sample volume, modification of equipment to obtain larger sample volume, or reaching agreement with USEPA and analytical laboratories to accept smaller sample volumes than specified in standard methods. None of these approaches is without problems or will satisfy every situation; it will be necessary to establish a decision framework collaboratively among USEPA CLP chemists and project team members.

5.3.3.1 Vertical Mixing

Vertical mixing of the sediments can be achieved by tidal flows, storms, wave action, boat traffic, and other non-biological processes, as well as by bioturbation. The effects of these physical processes cannot be easily discerned from those due to biota. However, the net effect of the various processes is essentially the same – to mix the uppermost layers of the sediment so they can be represented using a single net vertical mixing rate (*i.e.*, apparent bioturbation rate).

Disequilibrium of radioisotopes in sediments and porewaters compounded with a vertical mixing model are used to estimate the apparent bioturbation rates. Radioactive disequilibrium in this instance refers to the condition of having a higher concentration of daughter products than can be sustained by the decay of the parent isotopes present. Examples of radioisotopes that can measure bioturbation rates are lead-210 (Pb-210), beryllium-7 (Be-7), and thorium-234 (Th-234). Excess radioisotopes are present in surficial sediment due to scavenging from sea water. If the rate of deposition is greater than the rate of radioactive decay, then a sediment profile of radioactivity will show the depth of vertical mixing due to bioturbation and can be used to determine an approximate deposition rate. Be-7 and Th-234 activity can be measured in dry sediment from a core with a gamma spectrometer while Pb-210 activity can be measured with an alpha spectrometer.

To gain an understanding of the depth of sediment mixing and bioturbation rates, every third low resolution core will include 0-2 cm, 2-5 cm, 5-10 cm, and 10-30 cm intervals for radionuclide analysis.

A Sediment Profile Imagery (SPI) camera will be used in conjunction with sediment cores collected during geophysical surveys to evaluate benthic populations residing in the Lower Passaic River. This device provides a snapshot of organisms residing in the shallow sediments, thus aiding in delineating the biologically active zone (BAZ) and identifying benthos present.

5.3.4 Sediment Transport Investigation

The Sediment Transport Model that will be developed for the site (Refer to Section 7 – Hydrodynamic, Sediment Transport, Chemical Fate and Transport, and Bioaccumulation Modeling) will include sediment erosion, sediment transport, and deposition of both cohesive and non-cohesive sediments. Calibration of these processes requires that data be collected to determine site-specific values of parameters in the formulations describing these processes. The primary site characteristics that affect sediment stability are the shear stress at the river bottom under varying conditions and the physical properties of the upper sediment layers which can be affected by bioturbation. Bioturbation is discussed in Section 5.3.3 – Low Resolution Sediment Coring.

Sediment deposits can change significantly in spatial extent (both horizontal and vertical) and can be resuspended and redeposited by storms and other events (*e.g.*, dredging) that alter the river's hydraulic behavior. For the long-term prediction of both sediment and contaminant transport, one of the most significant processes to understand

and quantify is sediment erosion. These rates can change by orders of magnitude, not only as a function of the applied shear stress due to waves and currents, but also as a function of horizontal location and depth in the sediment. To model the Lower Passaic River tidal system, the sediment transport investigation will consider erosion, settling/flocculation and water column transport processes by conducting special sediment studies. These studies will include:

- <u>Sediment Erosion</u> – Cohesive sediment erosion is highly site-specific, requiring site - specific measurements to define parameters during model formulation for erosion. Erosion rates depend on the relative magnitude of the shear strength of the sediment and the shear stress exerted on the sediment surface. The shear strength can be affected by the following parameters: bulk density, particle size, mineralogy, organic content, pore water salinity, amount of gas, oxidation or other chemical reactions, and consolidation time. Erosion measurements involve specialized devices to characterize the erodibility of sediments in the Passaic River: (1) Gust Microcosm will be used to understand erosion with the surface; (2) SedFlume will be used to understand erosion at depth. The erodability experiments will be conducted in the field on cores collected from at least 15 locations in the river. Sediment cores will be collected using box corers for these experiments. After each core is collected, a Density Profiler (Gotthard, 1998) will be used to give a non-destructive and high resolution measurement of bulk density as a function of depth in the core. During the erosion test, small amounts of sediment will be removed at different depths in the core and used to determine the other bulk properties of the sediment sample including water content, grain size (using a Malvern Mastersizer) and organic content (Roberts, *et al*., 1998).
  - For the surface sediments, Gust Microcosm field experiments will be conducted to test for changes in surficial sediment erodibility over the range of 0-0.4 Pa (Pascals) applied shear stress. These erosion tests, which involve increasing shear stress through approximately eight levels, with each level of constant stress lasting approximately 20 minutes, will be performed according to protocols described in detail in Sanford and Maa (2001). Further details of these tests are provided in Attachment 4 of FSP Volume 1 (MPI, 2005b). These experiments will be conducted by the University of Maryland.
  - SedFlume experiments will be conducted on sediment cores to determine erosion rates as a function of depth and shear stress. This flume can measure erosion rates of sediments at high shear stresses [up to stresses on the order of 20 N/m^2 (Newtons per square meter)] and with depth (down to a meter or more). Therefore, SedFlume measures in-situ sediment erosion at shear stresses ranging from normal flow to flood conditions and with depth below the sediment/water interface. Protocols for conducting SedFlume experiments are described in McNeil, *et al*. (1996).
- <u>Sediment Settling/Floculation</u> – Settling is the downward movement of sediments through the water column due to gravity. In the case of cohesive sediments, flocs are formed by the process of flocculation which is the result of simultaneously occurring

aggregation and floc break-up processes. A combination of in-situ techniques are being considered to determine settling velocities of particles in the Passaic River. The first method is to conduct Modified Valeport Settling Tube experiments (Owen-type bottom withdrawal settling tube) on water column samples to determine suspended solids settling velocities. This instrument consists of a long slender tube which is lowered in the water in horizontal position to collect a water column sample. The protocols for determining the settling velocity using this tube are described in Sanford, *et al*. (2001). The second in-situ method includes the use of a laser in-situ scattering and transmissometry instrument system in combination with an optical backscatter sensor (OBS). These devices have been used to determine concentration and fall velocities of estuarine particle populations in the lower Chesapeake Bay, and the details are described in Fugate and Friedrichs (2002). The third method of in-situ measurement involves the use of a video settling tube that optically monitors the settling flocs in a vertical tube. In this system, suspended flocs are captured in a so-called capture/stilling chamber. Digital image analysis techniques have been developed to establish floc size and settling velocity distribution; protocols and floc structure from video recordings are described in Eisma (1996) and Dyer, *et al.* (1996).

- <u>Water Column Transport</u> – Water column transport consists of the movement of sediments in the water column. Monitoring the concentrations of sediments and the grain size distributions in the water column will be done during the hydrodynamic investigations and during field work associated with water body sampling for contaminants. Studies conducted by Feng, *et al.* (1999 a,b) and Ciffroy, *et al.* (2003) suggest that naturally occurring radionuclides can be used as tracers to understand the processes affecting particle dynamics in estuarine environments since the source terms and the rates of radioactive decay for these radionuclides are well known. Be-7 (half-life of 53 days) and Th-234 (half-life of 24 days), which both have a strong affinity for particle surfaces, were found useful in discerning short-term variations in the Hudson River Estuarine system. Using the protocols described in Feng, *et al.* (1999a,b) to determine the processes controlling the short-term fate and transport of particles within the Passaic River, two additional sampling efforts will be conducted. The first involves collecting large-volume water samples for analysis of Be-7 and Th-234 during the hydrodynamic investigations. The second involves obtaining surface sediment samples (0 to 0.5 cm), during the collection of sediment cores for the sediment erosion field experiments for Be-7 and Th-234. The radionuclide activities in the surface sediments will be used to understand the sources for the particles in the water column.

5.3.5 Sediment Sampling in Mudflats

Sediment sampling from semi-diurnally exposed mudflats within the Lower Passaic River will be conducted to determine the potential for adverse human health and ecological effects and further characterize the spatial extent of contamination. Unlike river sediments, mudflats are periodically exposed to varying degrees over the tidal cycle and therefore, could represent a higher potential for receptor exposure (*e.g.*, wading birds, shore birds, water fowl, mammals) to environmental contaminants via dermal contact and inadvertent ingestion.

There are three major objectives for sediment sampling from the mudflat areas:

- Contribute to the characterization of the spatial extent of contaminated sediments in the Lower Passaic River [(refer to DQO Subtopic Nos. 8 and 22 in Attachment 1.1 of the QAPP (MPI, 2005a)].
- Characterize the human health risk posed to anglers, transients, or other persons who may walk or wade along the mudflats of the Passaic River [refer to DQO Subtopic No. 15 in Attachment 1.1 of the QAPP (MPI, 2005a)].
- Characterize the ecological risks to plants, invertebrates, and fish that may live in or along the tidal mudflats or to animals that may incidentally contact contaminated sediments while foraging [refer to DQO Subtopic No. 20 in Attachment 1.1 of the QAPP (MPI, 2005a)].

Sediment samples will be collected to a depth of four feet. These samples will be analyzed for a variety of parameters that could include, but are not necessarily limited to: COPCs/COPECs, grain size, biological oxygen demand (BOD), pH, total organic carbon (TOC), Total Kjeldahl Nitrogen (TKN), phosphorus, and nutrients.

Mudflat samples will be collected from flat-bottomed boats (*e.g.*, johnboat, pontoon boat, Zodiac) during high tide. Mudflat sediment samples will be collected using hand coring devices (such as hand augers, piston samplers, or sampling triers). At each sample location, an attempt will be made to collect up to four feet of core material, or to the depth of refusal. If at any individual sample location the substrate is such that four feet of sample cannot be retrieved, then the core sample will be collected to the deepest depth practicable. If field sampling events indicate that use of hand-coring devices is not practical, then consideration may be given to collection of mudflat sediment samples using direct push technology (if accessible).

Particular care will be taken to collect samples above the sediment depth where the oxidation-reduction potential shifts from positive to negative (associated with the loss of oxygen with sediment depth). This boundary will be determined using a calibrated field oxidation-reduction potential probe to measure the boundary depth prior to sample collection. Visual cues, such as sediment color or texture that are determined to be useful in identifying this boundary depth, may also be used to expedite the sampling process. It is anticipated that the boundary will fall somewhere between 5 and 10 cm below the sediment surface, a depth that should roughly correspond to the bioactive zone as determined by radioisotopic geochemistry data.

Samples will be collected from areas identified as possibly being accessible by human receptors, known remnant marsh habitat of potential ecological significance, tributary confluences, and areas where mudflat habitat is evident from either recent study reports or as determined by review of available bathymetry data. The risk assessment needs will be primarily met based on the collection of surficial (as discussed in the following section) sediment samples. The need to evaluate ecological exposures to contaminants in deeper sediments will be determined following review of analytical data derived from sediment cores collected in 2005 as part of the high resolution, low resolution, and mudflat sediment coring tasks.

Based on the fine resolution of sediment cores (*i.e.*, 2 cm, 3, cm, 5 cm, 20 cm) required for hydrodynamic/risk assessment modeling needs, samples collected for analysis are likely to be of insufficient size (*e.g.*, volume, mass) to meet analytical laboratory requirements for minimum sample size, possibly affecting reporting limits. Possible solutions can include reducing the number of analytes requested, co-locating cores to obtain sufficient sample volume, modification of equipment to obtain larger sample volume, or reaching agreement with USEPA and analytical laboratories to accept smaller sample volumes than specified in the methods. None of these approaches is without problems or will satisfy every situation; it will be necessary to establish a decision framework collaboratively among USEPA CLP chemists and project team members.

5.4 HYDROLOGIC AND WATER QUALITY INVESTIGATIONS (PMP TASKS JAB, JFB)

Several different types of water samples will be collected during the LPRRP field investigation. Each type of sample is described below.

5.4.1 Hydrodynamic and Suspended Sediment Investigations

One of the important elements of the LPRRP is to develop and apply a scientifically-based model that incorporates hydrodynamic transport, sediment transport, contaminant fate and transport, and bioaccumulation processes. This Lower Passaic

River Model will be used as a tool for understanding historical and current sources and sinks of organic and inorganic contaminants in the Lower Passaic River and adjacent water bodies through mass balance analyses, as well as to provide the basis for an engineering evaluation of remedial and restoration alternatives. The goals of the hydrodynamic investigation are (1) to provide the baseline data set for calibrating and assessing the skill of the hydrodynamic components of the proposed Lower Passaic River Model, and (2) to characterize the aspects of the circulation and dispersive nature of the Lower Passaic River and describe how these processes change with tidal range and river discharge.

The activities that will be undertaken during this investigation include:

- Continuous monitoring using moored instrumentation installed at fixed stations within each reach of the Lower Passaic River. This will result in collection of a fixed-point time series of a variety of model calibration and evaluation data, including current velocities, salinity, and temperature.
- Shipboard CTD (conductivity, temperature and depth) under varying tidal and flow conditions. The data collected during the shipboard surveys will supplement the data obtained from the moorings, and will help characterize the strength of the tidal, two-layer flow in the Lower Passaic River by delineating the location of the salt wedge and stratification as a function of river flow. Figure 5-2 illustrates the locations of moorings as installed by MPI. These surveys will also provide intensive tracking of the salt wedge and its link to the estuarine turbidity maximum (ETM) zone.
- Cross-section ship-track surveys to provide information on cross-channel circulation, especially along river bends. These will also provide water quality cross-sectional distribution data that will be useful in assessing the model’s capability to simulate observed vertical and cross-channel shears in the flow. Assessment of the model’s capability to adequately simulate vertical and cross-channel shears in flow is critical since vertical and horizontal shears drive dispersion in a tidal riverine system.
- Total suspended solids (TSS) analysis of water column samples to gain an understanding of the transport of fine-grained sediments in order to predict contaminant fluxes (since most COPCs/COPECs will be adsorbed to particulates). In the Lower Passaic River, there are various processes that cause TSS concentration to vary over time including: turbulence, semi-diurnal tides, diurnal tides, other tidal harmonics, lower frequency tidal cycles, wind waves, watershed in?ow, and climatic variability.
- TSS sampling to identify the ETM zone; this is a region where the concentration of TSS may be a hundred times greater than concentrations both seaward and landward.
- Sampling for naturally occurring radionuclides to determine the processes controlling the short-term fate and transport of particles within the estuary, especially at the ETM.

Details (*e.g.*, data needs and rationale) of the hydrodynamic and sediment transport investigations are described in the Hydrodynamic Sampling Plan, presented in FSP Volume 1 (MPI, 2005b) as Attachment 4.

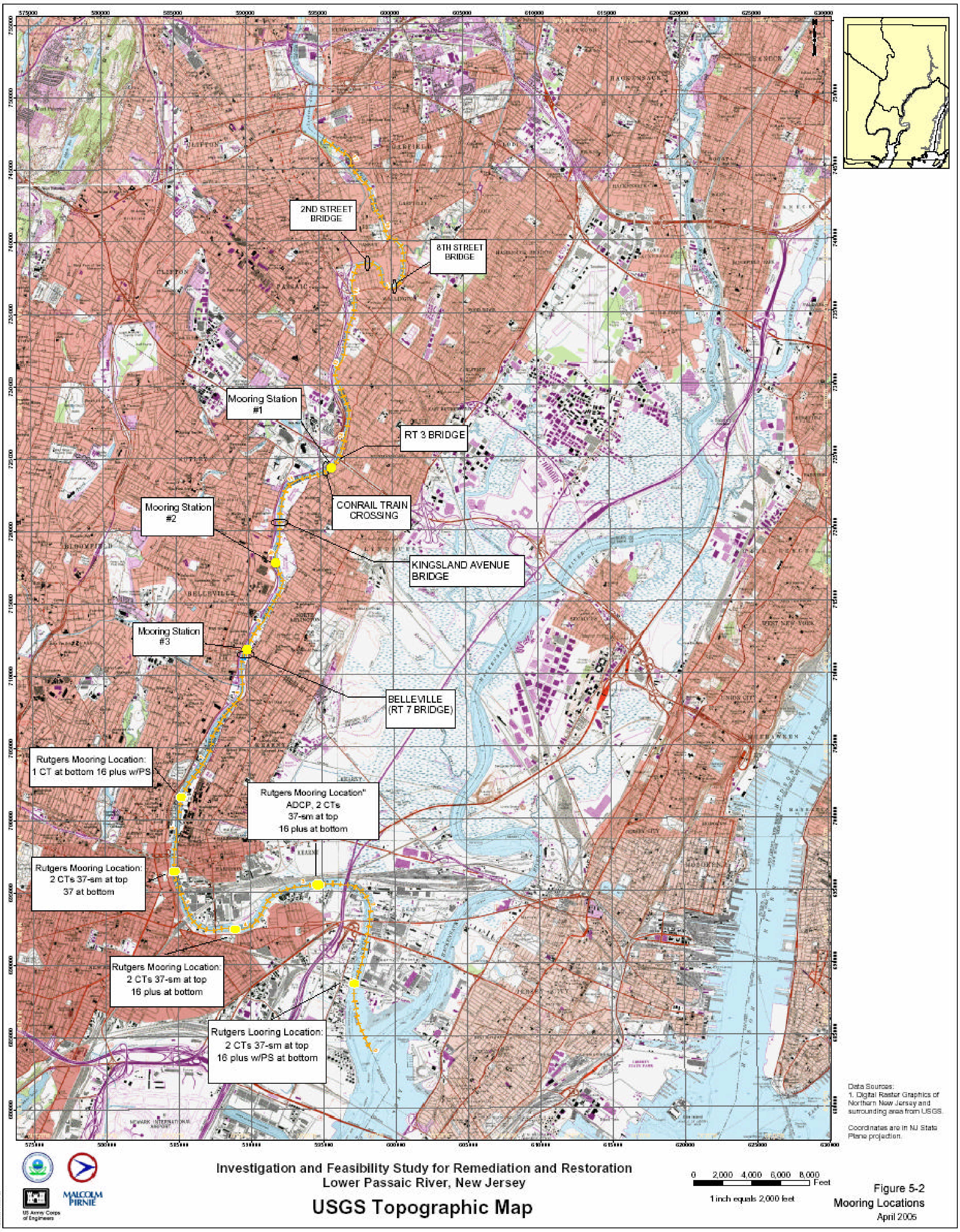


Figure 5-2: LPRRP – Mooring Locations

5.4.2 CSO Sampling

Combined sewers transport treated or untreated sanitary and industrial wastewater during dry weather conditions and combined wastewater and stormwater runoff during wet weather conditions. Typically, these waters are sent to municipal treatment facilities, [*i.e.*, publicly owned treatment works (POTW)]. However, when the capacity of a POTW is exceeded, untreated excess wastewater that cannot be treated at a POTW is typically diverted via regulatory chambers directly to the receiving water body(ies). The regulatory chambers are usually located where local sewerage districts join the CSO trunkline. In these cases, CSO effluent can contribute substantially to total chemical loading in a riverine system (USEPA, 1994; USEPA, 1980).

Details of the CSOs down-estuary of the Dundee Dam, including CSO name, location, and receiving water body are provided in Table 2-2 and Figures 1-5 and 1-6. The CSO sampling program will involve collection of wastewater and settleable solid samples from CSOs that discharge into the Lower Passaic River. The samples will be analyzed for COPCs/COPECs to provide information regarding the loads of COPCs/COPECs discharged to the Lower Passaic River from CSOs. The estimated COPC/COPEC load contributions from CSOs to the Lower Passaic River will be used for:

- Inputting COPCs/COPECs in the Passaic River modeling framework.
- Analyzing fate and transport of COPCs/COPECs.
- Evaluating the effectiveness of remedial alternatives in the FS.
- Assessing the potential for recontamination of remedial and restoration options.

5.4.3 Rising/Falling Tide Survey and Other Screening Level Investigations

Sampling of the water column via a Rising/Falling Tide Survey along portions of the 17-mile Lower Passaic River could enhance the current understanding of the locations of contaminated sediment deposits and point source discharges of contaminants and their impacts on the surface water quality of the Passaic River. The Rising/Falling Tide Survey is intended to function as a screening investigation to identify locations of concern by measuring gradients in water column chemical concentrations.

Sampling frequency will be dependent on the characteristics of the river, including the location of tributaries, CSOs, and point source discharges, but will likely entail collection of water column samples approximately every 0.25 mile of travel. In portions of the Lower Passaic River (*e.g.*, below the Harrison Reach), where the river is stratified between fresh water and salt water, separate surface and bottom water column samples will be collected to distinguish between fresh and saline water.

The Rising/Falling Tide Survey, which may include multiple, seasonal sampling efforts, is expected to aid in distinguishing point sources from existing contaminated sediment areas and in characterizing the distribution of contaminated sediment throughout the river and within the river's cross-section (*i.e.*, channel vs. shoals).

Several environmental gradients along the Lower Passaic River will be modeled with combined data from the Rising/Falling Tide Survey and from other hydrologic characterization and modeling activities (*e.g.*, water quality monitoring from installed moorings) associated with this WP. Additional monitoring data may be required from the shoal areas (*e.g.*, salinity) to model the contaminant migration due to tidal influence and mixing. Finally, data obtained from the Rising/Falling Tide Survey may be used to determine the locations of future sediment cores to further characterize the nature and extent of sediment contamination.

5.4.4 Tributary and Fixed Transect Water Column Sampling

There are many neighboring water body and tributary influences to the Lower Passaic River (*i.e.*, the Hackensack River, Saddle River, Third River, Second River, Franks Creek, Lawyer's Creek, Berry's Creek, Pierson Creek, Newark Bay, Arthur Kill, and Kill van Kull). Understanding the influence these water bodies have on the hydraulic properties and contaminant profile of the Lower Passaic River is necessary for modeling purposes and assessing the success of selected remedial actions. Water column samples will be collected from the tributaries to the Passaic River (Saddle River, Third River, Second River), and from the Hackensack River to characterize the boundary conditions/loads that affect the distribution of COPCs and COPECs by providing adequate information for the development and calibration of the Hydrodynamic and Fate and Transport Models [refer to DQO Subtopics Nos. 9 and 24 and the Data Needs/Data Uses Table in Attachment 1.1 of the QAPP (MPI, 2005a)].

Water column samples will be collected from fixed transects along the Passaic River will be conducted to characterize the hydrodynamic and hydrologic factors that affect the distribution of COPCs and COPECs, by providing adequate information for the development and calibration of the Hydrodynamic and Fate and Transport Models [refer to DQO Subtopics Nos. 7, 11, 15, and 20 and the Data Needs/Data Uses Table in Attachment 1.1 of the QAAP (MPI, 2005a)]

For tributaries that discharge to the model domain, the sampling program will entail monitoring the tributary discharge and collecting water column samples for COPCs/COPECs, TSS, particulate organic carbon (POC), DOC, and other general water quality parameters as specified in Section 5.4.3 – Rising/Falling Tide Survey and Other Screening Level Investigations. Discrete samples will also be collected to determine the dissolved and particulate phases of contaminants.

Furthermore, rating curves have been developed through the Contamination Assessment and Reduction Project (CARP) program for suspended sediment loads and sediment loads of various COPCs/COPECs from some tributaries that influence the Passaic River and adjacent waterbodies. To the extent that these rating curves are applicable, the data will be used to estimate loads of COPCs/COPECs. Additional data will be collected to develop similar curves for tributaries that were not sampled by the CARP program, as well as for upstream boundary COPC/COPEC and TSS loads transported over the Dundee Dam. Sampling in these tributaries will be done at the boundary of the model domain.

USEPA and other agencies are conducting or planning to conduct similar sampling programs within some of these water body influences *(e.g.*, Berry's Creek, Newark Bay). Activities within this WP and activities underway within the other water body influences will be shared across agencies and coordinated so that sampling and data overlap is avoided.

5.4.4.1 Fixed Transect

Six transects have been established for initial water column sampling in the Lower Passaic River. The transect locations and spacing were chosen based on tidal displacement and the location of tributaries and CSOs, and are described below:

- Transect 1, Mile 17 - down-estuary of Dundee Dam.

- Transect 2, Mile 15 - down-estuary of Saddle River.
- Transect 3, Mile 11 - down-estuary of Third River.
- Transect 4, Mile 8.5 - down-estuary of Second River.
- Transect 5, Mile 4 - down-estuary of CSOs near Newark.
- Transect 6, Mile 0 - Newark Bay.

At each transect, three water column sampling stations will be established across the river. Water column samples will be obtained from each station using grab samplers deployed from boats or bridges, or possibly via automated samplers installed on buoys. One station will be located in the channel and the other two stations will be located in the shoals.

The fixed station water column samples will be collected approximately one day per month. The monthly sampling may be somewhat regular or timed to capture specific events (*e.g.*, a high flow event such as a storm or a low flow event of interest such as an algal bloom). The sampling program will be conducted approximately monthly for one year to investigate seasonal variability. Further details of the sampling program are provided in FSP Volume 1, Section 3.7 – Fixed Transect Water Column Sampling (MPI, March 2005b).

5.4.4.2 Tributary Water Column Sampling

Four tributary sampling transects have been established for evaluation of boundary conditions/loads to the water column in the Study Area. The locations are as follows:

- Transect 7 – Saddle River.
- Transect 8 – Third River.
- Transect 9 – Second River.
- Transect 10 – Hackensack River (optional transect; need for sampling to be evaluated based on magnitude of freshwater flow over the Oradell Dam).

Within each tributary, a transect will be established in the farthest downstream point of the tributary’s freshwater flow. At each transect, three water column sampling stations will be established across the river. Water column samples will be obtained from each station using grab samplers deployed from boats or bridges, or possibly via automated samplers installed on buoys. One station will be located in the channel and the other two stations will be located in the shoals.

The tributary water column samples will be collected approximately one day per month (*i.e.*, the same day of the month as the fixed station water column sampling in the Passaic River). The sampling program will be conducted approximately monthly for one year to investigate seasonal variability. Details of the sampling program can be found in FSP Volume 1, Section 3.8 – Tributary Water Column Sampling (MPI, March 2005b).

5.5 SEDIMENT POREWATER AND GROUNDWATER SAMPLING (PMP TASK JFB)

The objective of the sediment porewater investigation is to provide information on the bioavailability of chemicals in sediments and the potential effects of contaminated sediment on infaunal species (*i.e.*, species that utilize habitats within the sediment matrix). Information on the bioavailability of the contaminants is necessary to address DQO Subtopic No. 20, regarding risks posed to ecological receptors by sediment contaminants. Porewater characterization is also to be conducted to characterize internal processes affecting COPCs and COPECs (refer to DQO Subtopic No. 10).

Porewater, defined as the water that occupies the spaces between sediment particles, can be isolated from the sediment matrix to conduct toxicity testing or to measure the concentration of COPCs and COPECs. The data collected in this study will be used to (1) determine the relationship between porewater and bulk sediment chemical concentrations and (2) understand the transport of COPCs/COPECs to the water column through chemical partitioning, diffusion, bioturbation, and/or resuspension processes.

Porewater sampling will be performed at locations where the sediment types range from sandy to uncompacted silt-clays since these sediment types have the highest potential interstitial water contamination. Areas with coarser particles or compacted clays will not be sampled. It has been reported by Sarda and Burton (1991) and SETAC (2001) that the two major issues of concern regarding porewater sample integrity are (1) the ability of the sampling device to maintain physicochemical conditions in the natural state by minimizing adsorption/leaching of chemicals to/from the device, and (2) the ability to maintain the sample in the existing redox state found at the site. Therefore, the aim of this sampling will be to utilize procedures that minimize changes to the in-situ condition of the water.

As part of the planning of the porewater investigation, a review of available groundwater data will be conducted to obtain more information regarding the general flow pattern. In addition, a literature search will be conducted to determine whether significant groundwater inputs occur in isolated areas or are better characterized as a regional concern. If groundwater is determined to be a significant contributor of contaminant loads, investigations of groundwater advection through the sediment will be planned and implemented along with the porewater investigation.

Porewater samples will be collected using in-situ methods such as "peepers" or dialysis cells for small volume samples and ex-situ methods such as centrifugation if larger volumes are required. The number of samples to be collected and sampling locations will be determined in 2005 based on initial low resolution and high resolution sediment coring and fixed transect water column sampling results.

5.6 ATMOSPHERIC DEPOSITION MONITORING (PMP TASK JFB)

Atmospheric deposition is the contribution of atmospheric pollutants or chemical constituents to land or water ecosystems. Atmospheric deposition monitoring data will be used to estimate atmospheric loads of chemicals into the open water surfaces of the Study Area. Deposition over land is accounted for via the stormwater runoff concentration and deposition over upstream water areas is accounted for via the tributary headwater concentration.

Atmospheric deposition is comprised of the following three components:

- Wet deposition accounts for materials transported via precipitation (*e.g.*, rain, fog, snow, dew, frost, hail) (Frick, *et al.*, 1998).
- Dry deposition accounts for chemicals which are deposited directly from the air (*e.g.*, dusts, aerosols, particles).
- Gas absorption refers to the process of gases being adsorbed onto the water surface from the atmosphere.

Atmospheric deposition loadings will be applied to the fate and transport model system based on data provided by the New Jersey Atmospheric Deposition Network (NJADN). The following NJADN stations are contained within the modeling grid developed for the LPRRP: Liberty State Park, Sandy Hook, New Brunswick, and Chester. Some or all of these stations may be used to estimate deposition trends over the open water areas.

Atmospheric deposition loadings to the model for the Lower Passaic River will use the CARP loading generation protocol and available NJADN data for the following chemicals: Total PCBs, PCB homologues, dioxin/furan congeners, PAHs, pesticides, and metals, including mercury. Representative chemicals from these chemical classes will be chosen for inclusion in the model based on physicochemical properties as well as modeling efficiencies.

Additional stations will be installed in the Study Area if sufficient monitoring stations are not available in the grid area defined for the modeling effort. Using the CARP experience as a guide, historical deposition fluxes for PCB homologues, gases, particles, and precipitation at each of the four stations are available from NJADN and may be applied directly to the CARP model. For mercury and cadmium, historical gas, particle, and precipitation flux data are available from NJADN on a harbor-wide basis; this was applied to the entire CARP model domain. For dioxin/furan congeners, NJADN did not calculate fluxes, but provided historical gas and particle concentration measurements for the Liberty State Park, Sandy Hook, and New Brunswick stations. NJADN protocols were used to develop the concentration measurements into fluxes. New Brunswick data were applied to both urban and northern, less urbanized tributary areas since Chester data were not available for dioxin/furan congeners.

5.7 CULTURAL RESOURCES REVIEW (PMP TASK JG)

This section discusses cultural resources surveys to be conducted in order to satisfy both CERCLA and WRDA requirements. To the extent possible, activities will be coordinated so that surveys can be merged into a single effort.

Section 106 of the National Historic Preservation Act of 1966 (as amended) requires federal agencies, or project sponsors seeking federal funding and/or permits, to take into account the effect of any undertaking on any cultural resource included in, or eligible for inclusion in, the National Register of Historic Places (NRHP). As federal agencies, the USACE and USEPA are responsible for the identification, protection and preservation of significant cultural resources within the Area of Potential Effects (APE) of any proposed project. For the LPRRP, the APE may include the riverbed and banks, as well as candidate restoration sites or construction staging areas. Significant cultural resources are any material remains of human activity that are listed on, or eligible for inclusion on the New Jersey State Register of Historic Places and NRHP. Other statutes and regulations specifically addressing these responsibilities include Section 101(b)(4) of the National Environmental Policy Act of 1969 and the Advisory Council Procedures for the Protection of Cultural Properties (36 CFR Part 800).

Project plans will be adjusted as practicable to avoid or minimize impacts to resources determined to be eligible for inclusion on the State and National Registers. An evaluation of the impact of alternative plans on eligible properties will be developed in consultation with the State Historical Preservation Officer (SHPO). If eligible resources cannot be avoided a Memorandum of Agreement (MOA) will be developed in consultation with the appropriate SHPO(s) to mitigate for unavoidable impacts. Any work stipulated in the MOA will be undertaken prior to initiation of project construction unless otherwise agreed with the SHPO(s).

Further details regarding the methodology for conducting cultural resources surveys are provided in Section 3.7 – Task 7 – Cultural Resources, of FSP Volume 3 (MPI, 2005c).

5.8 BIOTA AND ECOLOGICAL RISK SAMPLING (PMP TASKS JDE, JDN, JFB)

Biological surveys conducted as part of the investigation will serve or complement the following tasks identified in the Project Management Plan: Environmental Resource Inventory (Task JDE), Ecological Functional Assessment (included as part of Task JDN), and HTRW Site Inspection and Sediment Characterization Report (Task JFB).

Based on the data needs identified in the PAR (Battelle, 2004a), biota sampling will be conducted as described below. The objectives for this investigation which will be covered in FSP Volume 2 are to:

- Support the food web modeling for the ecological risk assessment by either field verifying bioaccumulation model results or providing actual whole body tissue concentrations of relevant prey species for inclusion in risk models.

- Support the ecological risk assessment by providing quantitative measures of the health and diversity of the aquatic community.
- Support the HHRA by either field verifying bioaccumulation model results or providing actual edible tissue concentrations for selected fish and shellfish species for inclusion in risk models.

5.8.1 Benthos Sampling

Surface sediment grabs will be collected from selected using one or more of the following techniques: Van Veen grab sampler, ponar grab sampler, Shipek, and box corer. Sediment samples will be sieved and a quantitative analysis of the benthic invertebrate community will be determined. The objective of this analysis will be to assess potential impacts of contaminants on the diversity and abundance of benthic macroinvertebrate species. Based on the enumeration of species present in each replicate sample, species richness and abundance can be determined for each location using a variety of diversity indices (*e.g.*, dominance, diversity richness, evenness). The results of this evaluation will provide a measure of the health of the benthic community and the potential population-level impacts of sediment-associated contaminants.

5.8.2 Fish and Shellfish Sampling

Based on the information presented in the PAR (Battelle, 2004a), representative species of forage fish, sport fish, and shellfish will be collected for the purpose of quantifying tissue concentrations of COPCs/COPECs for use in the human health and ecological risk assessment dose models. In addition, these data will provide qualitative information regarding the abundance and diversity of fish and shellfish species to evaluate population and community structure. Fish and shellfish collection techniques will be determined based on the target species and size class desired, but may include gill nets, trawl nets, traps, beach seines, and hook and line techniques.

For the human health assessment, edible tissue (*e.g.*, fillet) concentrations of selected sport fish and shellfish will be collected and evaluated for identified chemicals of concern. The specific species evaluated will be determined based on consideration of species most likely to be targeted by recreational anglers. These data will be used to quantify risks associated with consumption of fish, and to verify the results of bioaccumulation modeling.

For the ecological assessment, whole body concentrations of forage fish and other relevant fish and shellfish species will be required to either quantify the dose modeling or validate the results of the bioaccumulation model. The specific species to be targeted for evaluation will be representative of the prey species preferred by the final receptors of concern. In addition, whole body concentrations will be evaluated with respect to body burden concentrations reported to be associated with adverse effects on behavior, growth, reproduction, and survival for those chemicals for which data are available.

5.8.3 Bioassay Sediment Sampling

Based on the information provided in the PAR (Battelle, 2004a), laboratory bioassay testing is anticipated as part of the investigation to be conducted for the LPRRP. The objectives for the bioassay testing program may include:

- Support the ecological risk assessment outlined in the PAR in assessing effects to benthic invertebrates from exposure to COPECs.
- Establish a dose-response relationship between sediment COPEC concentrations and observed effects in benthic invertebrate receptors.
- Determine the transfer of sediment contaminants to benthic invertebrates (*i.e.*, bioaccumulation) to support the food-wed modeling and dose assessment for higher trophic level organisms identified as receptors of concern.

Bioassay sediment samples will be collected using one or more of the following techniques: Van Veen grab sampler, ponar grab sampler, Shipek, box corer, vibratory core sampler, and push corer to obtain adequate recovery and retrieve representative sediment samples. The type of sampling technique used will be selected based on the number and type of bioassay tests to be conducted and the complexity of the test design to ensure an efficient method of sampling to achieve the test volumes required. The method will also be influenced by the physical characteristics of the sediments and depth of sample required for the test.

Typically, bioassay tests are conducted on surface sediments representing the BAZ; generally the top 5 cm of sediment, although it is recognized that the BAZ may extend to 12-15 (30-38 cm) inches depending on the organisms being examined. Specific sample handling requirements are necessary to minimize and control for the introduction of confounding factors.

5.9 HABITAT DELINEATION AND ASSESSMENT (PMP TASK JDE)

Field investigations will be conducted to characterize ecological communities including SAV, wetlands, mudflats, and vegetated shoreline areas, both to support the ecological risk assessment and to document communities that may be disturbed or removed completely during potential future remedial actions. Obtaining adequate documentation to characterize these communities requires data collection regarding the size, location, and composition of the communities, as well as information on the sediment, soil, and hydrologic parameters that support the communities.

SAV habitat assessment and delineation will consist of several components. SAV beds located in or adjacent to contaminated sediment areas will be documented for species composition, location, and acreage. Sediment samples will be collected to analyze for TOC, grain size, pH, and macro- and micro-nutrients throughout the beds. Water quality measurements will include temperature, pH, turbidity, and DO. Finally, porewater chemistry samples will be taken to document baseline conditions in the beds.

Wetlands investigation along the Passaic River will focus on areas that are expected to be impacted by site contaminants and that are located in the river or entirely within 100 feet of the shoreline. Investigations will include wetland delineations, conducted in accordance with the 1987 USACE Wetland Delineation Manual (Environmental Laboratory, 1987), and wetland functional and value assessments which will be conducted utilizing the Hydrogeomorphic Approach (HGM) and the Evaluation for Planned Wetlands (EPW). The HGM, an assessment method developed by the USACE, typically produces a site wetland profile containing functional site characteristics that are compared with characteristics reference wetlands in the same region that are in the same geomorphic class as the investigated site. The EPW is a rapid assessment technique developed by Environmental Concern, Inc. Soil/sediment samples will be collected and analyzed for physical and chemical parameters, including organic and nutrient content. A survey will be conducted to determine if threatened/endangered species and or any ecologically significant habitats are present in the project area. The proposed action will conform with pertinent state and federal permit requirements.

Shoreline areas will be evaluated for community characteristics and physical, chemical, and hydrologic conditions. Reference shoreline communities will be described by species composition, age, and density along transects established by project field personnel. Soil samples will be collected and analyzed in a manner similar to that of SAV and wetland samples and will include soil characterization based on USGS Soil Survey data.

5.10 CANDIDATE RESTORATION SITE SAMPLING (PMP TASK JD)

The proposed restoration projects will incorporate a watershed-based approach to effectively restore and protect aquatic resources. Emphasis under the watershed approach is directed at all aspects of surface and ground water quality including physical, chemical, and biological parameters. The watershed approach is action-oriented, driven by broad environmental objectives, and involves key stakeholders. The major cornerstones of the approach are public participation, problem identification, and implementation of restoration projects. This section addresses restoration investigations for in-river sites, riparian sites, tributaries, and other wetlands in the watershed. Additional details of candidate restoration site sampling activities are provided in FSP Volume 3 (MPI, 2005c).

5.10.1 Candidate Restoration Sites Soil and Sediment Investigations

Future data needs for candidate restoration sites will encompass both geotechnical and environmental sampling to satisfy the following objectives:

- Determine whether candidate site soil/sediment contaminant concentrations exceed NJDEP Site Remediation Criteria and/or are likely to have an adverse impact on site restoration (*e.g.*, plantings, biota).
- Determine candidate site soil/sediment geotechnical properties to support restoration feasibility analyses.
- Determine soil geotechnical properties in Passaic River bank areas to evaluate slope stability and whether bank stabilization measures may be required during remedial dredging.
- Provide data necessary for the affected environment section of the National Environmental Policy Act (NEPA) Environmental Impact Statement (EIS).

Based on these data needs, once restoration sites are selected, a detailed sampling program will be developed in consideration of site-specific conditions. Presented below is an overview of studies and sampling methodologies that are likely to be performed at candidate restoration sites.

- Geotechnical Investigation – Specific geotechnical testing will be performed to quantify in-situ soil and sediment properties at areas selected for shoreline softening, public access, and also for areas selected for wetland restoration/rehabilitation. Geotechnical engineering studies will be performed for slope stability analysis of the shoreline, re-contouring of wetlands sediment, construction of bulkheads along the riverbanks, the removal of riprap and contouring of the riverbank. Geotechnical analyses may also be conducted in areas other than candidate restoration sites where information is necessary to assess the potential impacts of contaminated sediment dredging on shoreline slope stability.
- Hazardous/Toxic/Radiological Waste (HTRW) Investigation – In addition to the detailed HTRW sediment investigations described in Section 5.3 – Sediment Investigations, it is anticipated that additional investigations may be necessary outside of those areas (*e.g.*, wetlands, tributaries) for establishing baseline characteristics of candidate restoration sites. Such investigations will be conducted in accordance with guidance provided in "Water Resources Policies and Authorities – Hazardous, Toxic and Radioactive Waste Guidance for Civil Works Projects" (EM 1165-2-132; USACE, 1992), "Engineering and Design - Requirements for the Preparation of SAPs" (EM 200-1-3; USACE, 2001a), and CERCLA RI guidance. A report will be prepared which describes detected HTRW occurrences within, or nearby, the project areas. It will include a preliminary determination of the nature and extent of detected contamination as well as quantitative and qualitative analyses of contamination impacts in the absence of response actions. HTRW site inspections will be conducted for the ecosystem restoration projects in support of alternative plan development. Soil samples may be collected using conventional drilling rigs, or direct push technology (DPT).

5.10.2 Candidate Restoration Sites Water Quality Investigations

Future data needs for selected restoration sites will encompass both water quality and HTRW sampling to satisfy the following objectives:

- Determine whether groundwater/surface water contaminant concentrations exceed NAWQC and NJ Surface Water Quality Standards and Groundwater Quality Standards and/or are likely to have an adverse impact on site restoration (*e.g.*, plantings, biota).
- Provide data necessary for the affected environment section of the NEPA-EIS.

5.10.3 Candidate Restoration Sites Socioeconomic Analyses

The objective of socioeconomic analyses is to measure the cost effectiveness, social fairness, and institutional implementability of each remediation and restoration plan proposed for the contaminated environmental media in the Lower Passaic River and the candidate restoration sites. The study period for all evaluations will be 50 years, consistent with the Project Management Plan [PMP (USACE, *et al.*, 2003)].

5.10.4 Candidate Restoration Sites Real Estate Surveys

According to USACE's "Real Estate Handbook" (USACE, 1985), a Real Estate Plan (REP) is the real estate work product that supports project plan formulation. It identifies and describes the lands, easements, and rights-of-way (LER) required for the construction, operation, and maintenance of a proposed project, including those required for relocations, borrow material, and dredged or excavated material disposal.

Real estate surveys will be performed for candidate restoration sites. The real estate surveys will be performed to identify ownership, site boundaries, easements, rights-of-way, utilities, etc. Real estate and planning personnel will work on the following elements of the real estate needs as identified in the PMP [(USACE, *et al.*, 2003)]:

- Real Estate Supplement.
- Gross Appraisal.
- Preliminary Real Estate Acquisition Maps.
- Physical Takings Analysis.
- Preliminary Attorney's Opinion of Compensability.
- Rights of Entry.
- Other Real Estate Documents.

5.10.5 Investigations of In-River and Tributary Restoration Sites (PMP Task JDE)

It is anticipated that in addition to characterizing the contaminant impact to biota, FSP Volume 2 activities will also characterize the diversity and abundance of the aquatic benthic communities. In addition to those described above, techniques may include:

- Fish surveys.
- Avian surveys.
- Benthic community surveys (*e.g.*, SPI).
- Other habitat delineation techniques (*e.g.*, geophysical surveys).
- Analyses to determine sediment health (*e.g.*, pH, redox, DO, TOC, nutrients).

The data collected from these techniques will also be used as a basis for conceptual design for restoration, and will enable consideration of potential restored sites to attract sensitive receptors.

Benthic grab data and SPI data will be taken to document the distribution and occurrence of benthic habitats and invertebrate communities within the Lower Passaic River. Photographic inspections of the top 18 cm of the sediment will be performed at 138 locations using SPI (the SPI camera will be deployed twice per station). The locations are one half of the shallow core locations sampled in the SSS ground-truthing task (see Section 5.2.2 – Geophysical Surveying). At 25% of these locations, a grab sample of the top 6 inches of sediment will be collected for evaluation of the benthic community.

5.11 ENVIRONMENTAL DREDGING AND SEDIMENT DECONTAMINATION TECHNOLOGIES PILOT (PMP TASK JAE)

A pilot-scale dredging demonstration project coupled with a pilot-scale sediment decontamination technology demonstration project will be conducted in the Lower Passaic River. The objectives of the dredging demonstration project are to collect data on equipment performance, dredging productivity, and sediment resuspension as input to the FS evaluation of remedial and restoration alternatives. The objective of the sediment decontamination technologies pilot is to determine whether Passaic River sediments can be treated to produce an economically viable beneficial end use product.

Using environmental dredging, 5,000 cubic yards of sediment will be removed from the Harrison Reach and delivered to two decontamination technology facilities (one thermal treatment and one sediment washing). The 1.5-acre dredging location was chosen using data from geophysical, sediment coring, magnetometer, SSS, and sub-bottom profiling surveys focused in the Harrison Reach. A hydrodynamic survey determined that the optimal time for the dredging pilot will be at neap tide to minimize ambient resuspension of sediments so that the signal from the resuspension caused by dredging can be monitored. A near-field plume model is being used to determine locations of resuspension monitoring equipment.

6.0 DATA PRESENTATION

6.1 PROJECT DATABASE OVERVIEW

The Passaic River Estuary Management Information System (PREmis) is an internal project website designed to collect, store, manage and report historical data, as well as data and information that will be collected during the LPRRP. PREmis also provides effective project communication and coordination among the six partner agencies and associated consultants.

A centralized, web-based portal to the various forms of electronic information collected and stored for the project has been developed. At present, PREmis provides project team members access to information on project contacts, schedules, communications, project management, historical information, planning documents, and GIS mapping and reports. Since PREmis was created in a modular format, it can be upgraded as needed as the project proceeds. Also, the project-related information that is ready for release is made available to the public through the following website interface: www.ourPassaic.org.

6.2 OBJECTIVES

The main objectives for PREmis are to:

- Provide a central location for project information including large volumes of electronic field data.
- Provide timely access to data and documents for project team members.
- Deliver a variety of reports in a variety of formats, from on-screen tabular web reports and downloadable data sets for off-line analysis to GIS-based visual reports.
- Maintain defensible information through security safeguards.
- Allow different levels of users to access the site through a multi-tiered security plan.
- Track data and documents through on-line validation, review, and approval processes from remote locations.
- Automate the capture of field data.

6.3 PREMIS DESCRIPTION

The system uses a combination of different technologies, including:

- MapGuide, a web-based GIS interface to display analytical and shape file data.
- ColdFusion as the main programming environment.
- Various Internet technologies to upload, download, and report information.

To facilitate communication among team members on a real-time basis, the system allows members from the consulting team operating in various offices, the six partner agencies, and field crews to enter, manage, and report data. The flowchart of how data presentation will be handled by PREmis is presented in Figure 6-1. The use of Internet technologies such as Web Servers, Web Browsers, Firewalls, and e-mail provides the type of flexibility and security needed for this system.

Users have access to the system via standard Web Browsers and log on to a private web server located in MPI’s White Plains, NY office. All users have separate login identifications and passwords, and have been assigned to different user access levels. All data for the system are stored in ColdFusion and are accessible through both pre-defined reports and ad-hoc query capabilities. Data download capabilities have also been added as part of the reporting area.

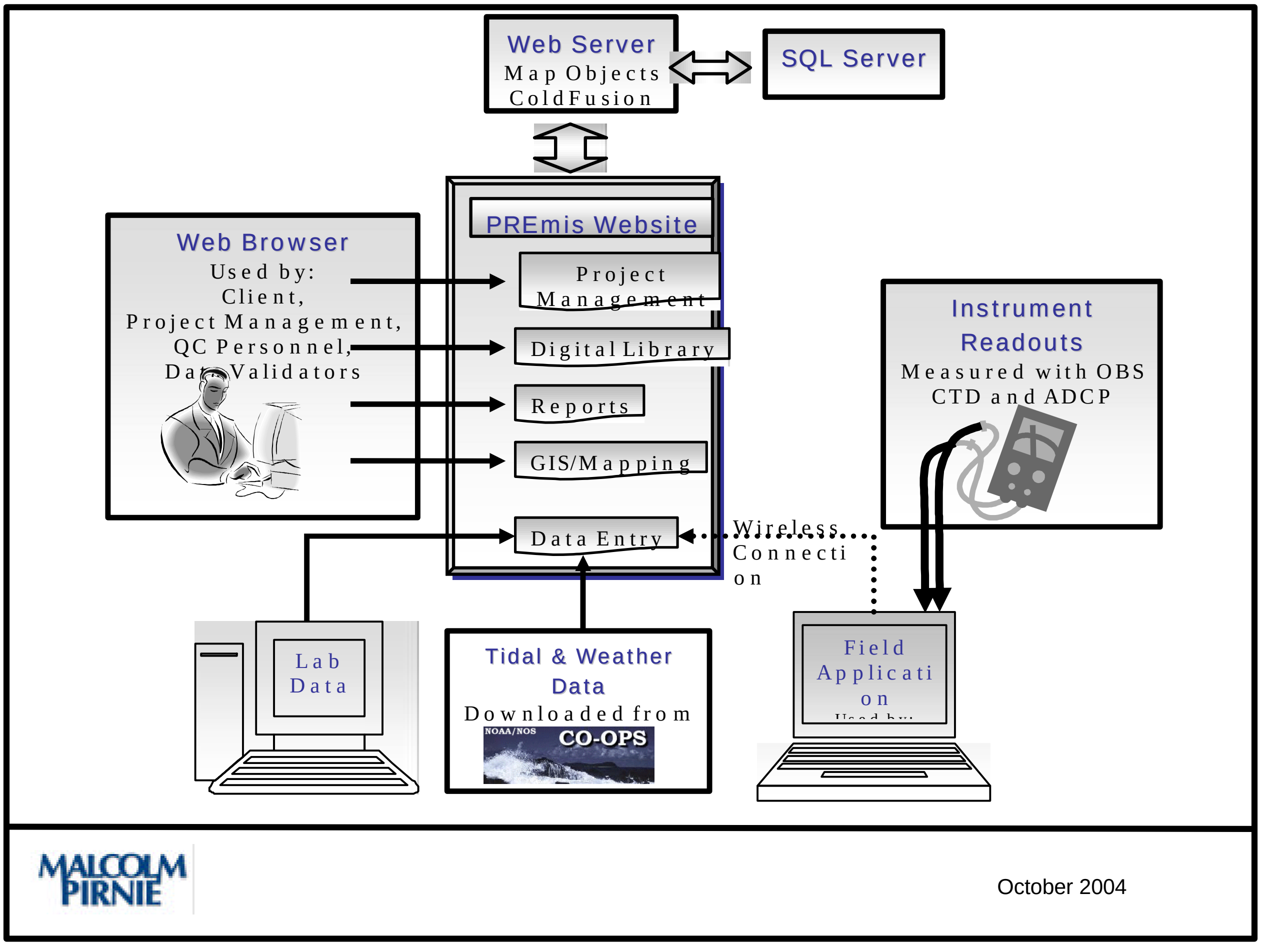


Figure 6-1: LPRRP – Data Presentation Flow Chart

6.4 PREMIS UTILITIES

PREmis uses the following modules for this project:

6.4.1 Management

This module includes budget tracking, scheduling, and project task tracking, as well as a platform for performing task-specific discussions. The reporting function of PREmis also assists in project management by allowing users to generate key management reports.

6.4.2 Data Storage

PREmis provides a platform for the electronic storage of documents and information. The documents are stored in the digital library and are coded with attributes that allow users to query the reports based on key words. The information is contained in a unified database that was developed to be consistent with USEPA's Multimedia Electronics Data Deliverable (MEDD) requirements. This database will be the repository for all historical data as well as data collected during on-going project activities.

The digital library also allows users to save documents and information that need to be available to authorized users in the general public. An option for marking the document as a public document is available in PREmis when storing the documents into the digital library. Once the document is marked public, it is available for viewing and downloading from the ourPassaic.org website.

6.4.3 Data Upload and Validation

The data upload function of PREmis allows users to upload data from various sources such as laboratory electronic data deliverables (EDDs) and field instrument readouts. The interactive module allows users to upload American Standard Code for Information Interchange (ASCII) files containing data directly into the website; the data are then reviewed and approved by the site quality control officer (SQO) prior to being available to the entire project team.

6.4.3.1 Field Application

The field application allows users to collect field information electronically instead of manually into field notebooks. The field application will be used by the sampling teams while performing field sampling of the Lower Passaic River and its tributaries. The field application is able to support different sampling events (*e.g.*, surface water/water column sampling, sediment sampling, hydrodynamic monitoring) through the creation of sample-specific modules. The field application will also allow users to periodically download instrument readouts from various sampling instruments and will assist in uploading the information into the PREmis database after the data have been reviewed and approved by the SQO or a designee.

6.4.3.2 Laboratory Data Upload

The laboratory data upload section of PREmis will provide the ability to define and save EDD formats. Access to the laboratory upload section will be limited to lab personnel and members of the team involved with laboratory data QA/QC. The user can then select the EDD format, browse his or her computer for the EDD file, identify the file type (Excel or ASCII) and then upload to the website. Appropriate initial checks of the file will be performed. If either of the checks fails, then the upload will be aborted. The user will be alerted as to the reason the process was aborted and resolution suggestions will be displayed.

Following these checks, the file will be copied to the digital library. The EDD will be parsed out and inserted into the PREmis database. Rows of data successfully inserted will be reported back to the user for review. Rows that are rejected will also be reported in an exception report. An email will be sent to the user and the laboratory QA/QC officer with the name of the EDD and a copy of the exception report.

When a laboratory EDD containing errors is corrected and re-uploaded, only those results that do not already exist in the PREmis database will be added. Therefore, unchanged results will not be updated.

6.4.3.3 Laboratory Data Validation

Laboratory data will be validated and approved via PREmis. Access to the laboratory validation section will be limited to validators and the SQO. The laboratory validation section will provide validators and the SQO the ability to pick a laboratory EDD and modify results, qualifiers, and add data validator qualifiers to indicate data validity. The validators and SQO will follow the same process. The process will involve:

- Selection of the EDD that is to be validated or approved.
- Download of that data in an Excel file to the validator’s or SQO’s computer.
- Upload of the modified Excel file to the website.
- Confirmation of changes on the website.
- Marking the status of the EDD.

The validators will only see EDDs that are awaiting validation while the SQO will see a list of EDDs that have been validated and are awaiting approval, and EDDs that are awaiting validation. The user can select the EDD and download an Excel copy to his or her computer. Once the validation process is complete, the user will navigate back to the validation page and upload the modified file. The uploaded Excel file will go through checks to confirm that samples match for the selected EDD. If the integrity checks pass, then the modified results and qualifiers will be presented to the user for confirmation.

When the user confirms the changes, the information is written to the database and audit records are created to capture the original values and identify who changed the values and when. If the validator is uploading an EDD, it is marked as "Validated." If the SQO is uploading an EDD, s/he will have a choice to select "Approved" or "Rejected." Once the SQO marks an EDD as "Approved" or "Rejected," the final status of the EDD is marked as "Validated & Approved", "Not Validated & Approved," or "Rejected". Validated data that are ready for release are made available through a link to the public website www.ourPassaic.org.

6.4.4 Evaluation

The GIS Mapping/Map Guide and report functions of PREmis will assist the project team in assessing problems, formulating and evaluating solutions, and presenting findings. The GIS Mapping/Map Guide portion of PREmis provides a means for all project team members to easily access, display and query map and sample data stored in either ESRI shape files or the PREmis database. The report tool will assist users in querying information based on various attributes. Map Guide is also available on the public website www.ourPassaic.org.

6.4.4.1 GIS Mapping/Map Guide

With its interactive spatial query tool, GIS Mapping/Map Guide allows users to query information based on a selected area and then view related reports, documents, and data. It also gives users the ability to create custom spatial views of data and allows users to save their custom views of data to a personal library. By saving their MapGuide data views, users can simply pick a saved view from their personal list and MapGuide will automatically retrieve and display the results. In addition, users have the ability to save their personal data views to a public list, enabling other team members to see their MapGuide results rather than re-creating them.

To assist team members in their analysis of sample data, a MapGuide interface displays various GIS data layers and sample data stored in the PREmis database. These data layers, referred to as themes, are stored in the shape files and viewed through MapGuide. Themes that may be included in PREmis include soils, vegetative cover, wetlands, topography, hydrology, tidal reach and elevations, water and sediment quality sample locations, property ownership, land use/cover, zoning, demographic data, regulatory floodplain boundaries, stream bathymetry, HTRW, and cultural sites information. At present, the interface gives users the ability to:

- Turn off and on various map themes incorporated into the shape files.
- Customize the MapGuide display of sample data results.
- Create ad-hoc queries for sample data by date, chemical class, location (*e.g.*, township, river mile, reach), sample type, depth and evaluation criteria such as those reflected in Applicable or Relevant and Appropriate Requirements (ARARs) determined for the project.
- Drill down into sample results for a particular location.
- Create and store custom MapGuide “views” by user.
- Generate tabular reports from selected data.
- Download sample data into either Microsoft Access or Excel.

7.0 HYDRODYNAMIC, SEDIMENT TRANSPORT, CHEMICAL FATE AND TRANSPORT, AND BIOACCUMULATION MODELING

7.1 OVERVIEW

A set of models designed to simulate the physical, chemical, and biological processes occurring within the Study Area is being implemented to evaluate the risks posed to human health and the environment from the transport of sediment and associated contaminants and various remedial alternatives developed to address the risks. The integrated modeling framework is needed to determine the fate of contaminants released into the environment under both current conditions and future scenarios, and thus to produce scientifically defensible support for regulatory decision-making.

7.2 PURPOSE AND OBJECTIVE OF THE LOWER PASSAIC RIVER MODELING (PMP TASK JAF)

The main purpose of the modeling effort is to spatially and temporally interpolate available information and predict future concentrations of the COPCs/COPECs in the Study Area under a baseline (or No Action) scenario and under different management scenarios. Specifically, the model will be used to establish the magnitudes and relative importance of specific contaminant sources to the 17-mile tidal reach of the Passaic River, including:

- Upstream loads from above the Dundee Dam.
- Loads from tributaries and other point sources along the 17-mile tidal reach.
- Re-mobilization of contaminants within the 17-mile tidal reach.
- Inputs from water bodies hydraulically connected to the down-estuary end of the 17-mile tidal reach via Newark Bay.
- Surface runoff.
- Non-point sources.
- Point sources.

The models will also provide management guidance for the adverse ecological and human health effects of the transport and ultimate fate of the COPCs/COPECs within the system. The models will provide data for use in the development of the baseline human health and ecological risk assessments for the project. Additionally, the models will be used to assess the fate of sediment and chemical contaminant re-mobilization due to various remedial action alternatives that may be conducted within the Lower Passaic River during the period of remediation, as well as during the recovery period. Lastly, the models will be used to assess sediment quality and contaminant levels if loadings are reduced or eliminated, and the time frame for improvement under various remedial action alternatives.

7.3 MODEL FRAMEWORK AND APPROACH

The model domain encompasses the Passaic River, Hackensack River, Newark Bay, their tributaries, and portions of the Arthur Kill and Kill Van Kull. The model must extend to include a portion of New York Harbor to avoid boundary effects that will contaminate the model in the region of interest. The existing CARP model, developed for the NY/NJ Harbor Estuary Program, will be used to determine the outer most extent of the modeling domain. The model framework used for the Lower Passaic River Modeling Study includes model components describing hydrodynamics, sediment transport and organic carbon cycling, chemical fate and transport, and bioaccumulation as shown in Figure 7-1.

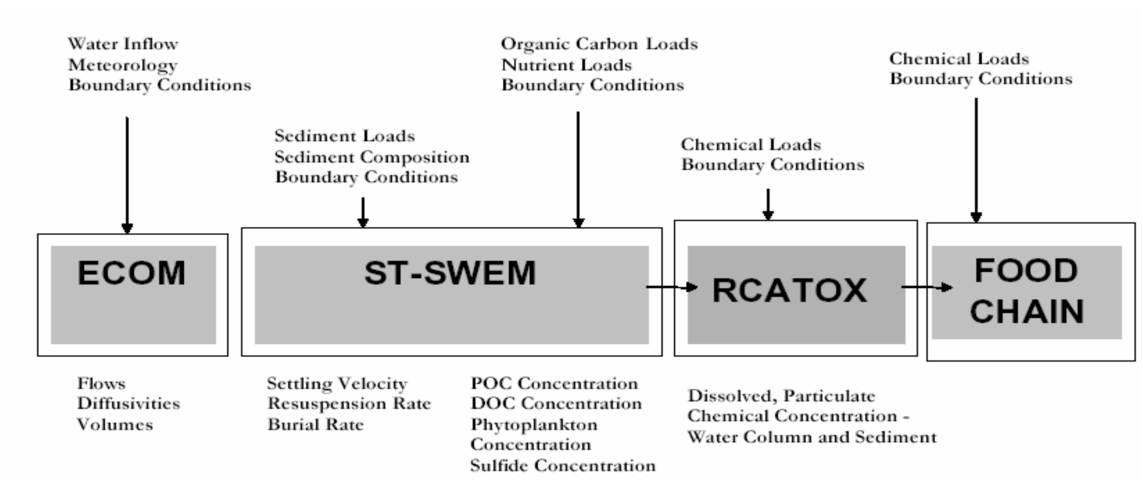


Figure 7-1: LPRRP – Model Framework

The model will be run with a fine spatial and temporal resolution with the capability of capturing the dynamics of individual storm events as well as long-term fate and transport and bioaccumulation processes. For computational efficiency, the overall modeling calculations will be decoupled and performed in four successive model calculations as described below.

Hydrodynamic model calculations will first be performed to determine intra-tidal transport, currents, and bottom shear stresses throughout the model domain. This portion of the model suite uses the model inputs of flow upstream and from tributary inputs, downstream tidal action, temperature, and salinity, as well as atmospheric inputs such as wind speed and solar radiation to simulate the flow, dispersion, stratification, and currents within the estuary. In addition to transporting material by advection, the flow imparts a shear stress on the bed, which at a threshold value determined by the bed properties such as porosity and grain-size distribution, will re-mobilize the bed sediments and associated contaminants.

This information will be passed forward to a sediment transport/organic carbon cycling model to determine the movement of inorganic particles and organic carbon between the overlying water and the bed. Organic carbon cycling is considered explicitly with sediment transport for three important reasons. The first reason is that POC can be a significant part of the suspended sediment concentrations, particularly in surface waters of the harbor. Secondly, POC can affect the movement of inorganic particles through coagulation, resuspension, and sediment mixing processes. Third, organic carbon and not sediment *per se*, is important in controlling the distribution of toxic contaminants between the dissolved and particulate phases in subsequent model calculations.

In turn, information from the hydrodynamic and sediment transport/organic carbon cycling models will be passed forward to a chemical fate and transport model, and will be used along with descriptions of contaminant partitioning to organic carbon and other contaminant processes (*e.g.*, volatilization, degradation) to determine contaminant concentrations in the overlying water and sediment. Finally, contaminant concentrations in the water column and sediment will be used in bioaccumulation and food chain models.

The specific models that will be used are shown in Figure 7-1. A summary of processes included in the various models and detailed model descriptions for these processes is described in the Modeling WP (HydroQual, 2004). Model calibration for the hydrodynamic and sediment transport/organic carbon cycling models will be performed for select USGS water years (October-September). The most rigorous test of the sediment transport model will be conducted as part of hindcast simulation for Cs-137) through the evaluation of spatial patterns in sedimentation rates computed over approximately 50 years. Chemical fate and bioaccumulation model calibration for the COPCs/COPECs will be performed for present conditions. These evaluations form the basis for an overall assessment of the model. Further, component load analyses and model projections (scenarios) under various scenarios will be performed and compared with the above described base runs. Details of model calibration, assessment, load analyses and projections are described in the Modeling WP (HydroQual, 2004).

8.0 RISK ASSESSMENT

8.1 OVERVIEW

Human health and ecological risk assessments will be conducted for the LPRRP (PMP Task JDE). Risk assessments are performed to assess the potential threat to current and future human health and the environment in the absence of any remedial actions or institutional controls. Results of the risk assessments will be used to assist in the risk management decisions for the site.

Prior to initiating the risk assessments, a Pathways Analysis Report (PAR, Battelle, 2004a) was prepared as a preliminary planning document, based on evaluation of historical data. Included in the PAR was an assessment of the temporal and spatial data gaps associated with the historical data as well as the identification of the exposure pathways, receptors, and exposure assumptions for both the human health and ecological risk assessments. The PAR was developed with input from all agencies involved with the project. Because of the iterative nature of the field investigation for this site, updates or revisions to information (*e.g.*, exposure pathways and assumptions, chemicals) provided in the PAR may need to be made as additional studies are completed and more data become available.

An overview of the risk assessment approach is provided below. Where appropriate, reference to the existing PAR (Battelle, 2004a) is made to provide more information regarding site-specific exposure assumptions and risk assessment methodology. The sections below provide a detailed description of the risk assessment approach. Risk assessment activities will incorporate new data as well as the results of efforts to refine exposure assumptions such as fish and shellfish consumption rates, site use factors, and exposure duration.

8.2 SCREENING ASSESSMENT

As the initial step in the risk assessment process, contaminant levels in the relevant environmental media will be screened against risk-based concentrations to identify chemicals of potential concern (COPCs) for human receptors and chemicals of potential ecological concern COPECs for ecological receptors. The selection process for identifying COPCs and COPECs is summarized below in Section 8.2.1 for human receptors and Section 8.2.2 for ecological receptors. In addition, summaries of the screening process are provided in Section 3.2 – Preliminary Conceptual Site Model, and Figure 3-1 through 3-3 in this WP, for human and ecological receptors.

8.2.1 Human Health Screening Process

In general, the screening process will consist of comparing the maximum concentration of each analyte against conservative risk-based concentrations to identify COPCs for the risk assessment. Risk-based levels will be obtained from current USEPA Region 9 PRGs (USEPA, 2004a) and USEPA Region 3 Risk-Based Concentrations (USEPA, 2004b), or derived based on exposure assumptions described in the PAR (Battelle, 2004a). Since the PRGs and Risk-Based Concentrations are periodically updated based on reviews for toxicity information, as the investigation proceeds through time, rescreening of the chemicals may be necessary as PRGs and Risk-Based Concentrations are updated. Chemicals with maximum concentrations exceeding the Risk-Based Concentrations will be identified as COPCs, while chemicals with concentrations below these screening values may be excluded from further analysis as indicated in the additional screening criteria below:

- When risk-based concentrations are not available, the chemical will be retained as a COPC.
- Background and ambient conditions will not be considered in the selection of COPCs, but will be considered in the risk characterization portion of the risk assessment consistent with USEPA's Background Guidance and RAGS Part A guidance (USEPA, 1989).
- All Class A carcinogens will be considered COPCs in future evaluations and will be included in any sampling program regardless of their frequency of detection or presence below risk-based concentrations.
- Chemicals not identified as Class A carcinogens can be excluded from further evaluation if they are detected in less than five percent of the samples collected, with sample sizes of 20 or more and no localized contamination (*e.g.*, hot spot) is evident.
- Inorganic chemicals that are considered macro-nutrients (*e.g.*, calcium, potassium, sodium, magnesium, and phosphate) will be excluded as COPCs.
- Inorganic chemicals that are considered essential micro-nutrients (*e.g.*, iron, manganese, copper, molybdenum, zinc, selenium, chromium, and cobalt) will be selected as COPCs if maximum concentrations exceed the risk-based concentrations.

8.2.2 Ecological Screening Process

The process for screening chemical constituents for the protection of ecological receptors consists of three tiers that include: 1) essential nutrient screen; 2) effects benchmark screen; and 3) bioaccumulation screen. Maximum concentrations of all chemicals will be used for this screening process.

- The frequency of detection of each chemical will not be used as a criterion to determine COPECs, but low frequency of detection will be evaluated on a case-by-case basis to determine grouping or pattern occurrences prior to being screened out. Chemicals with a low frequency of detection will be evaluated on a case-by-case basis to determine grouping or pattern occurrences, so as not to screen out potential "hot spots".
- Constituents considered to be 'essential nutrients' (*e.g.*, phosphorous, potassium) will be excluded from consideration as COPECs.
- The maximum sediment concentrations of all non-essential nutrients detected in greater than five percent of samples with sample sizes of 20 or more will be screened against a hierarchy of effects-based sediment benchmarks. This evaluation will be based preferentially on SQGs developed by NOAA (1991) which defines two screening benchmarks, the ER-L and ER-M (Long and Morgan, 1991; Long, *et al*., 1995).
- Constituents for which NOAA benchmarks are unavailable will be screened against other available effects-based benchmarks including those developed or recommended by ORNL in Jones, *et al*. (1997), Florida Department of Environmental Protection (FDEP) (MacDonald, 1994), and USEPA (USEPA, 1993, 1996).
- Chemicals for which no effects-based sediment benchmark values are readily available will be retained as COPECs. As part of future risk assessment activities, a literature review will be conducted to identify appropriate screening values for chemicals lacking benchmarks.
- To provide confidence that bioaccumulative compounds are adequately addressed, chemical constituents detected in greater than five percent of samples with sample sizes of 20 or more will be compared with a list of bioaccumulative compounds published by USEPA Region 9 (Hoffman, 1998). Any Region 9 bioaccumulative constituent that is detected in greater than five percent of samples will be identified as a COPC, regardless of its concentration relative to its respective effects-based benchmark value.

8.3 HUMAN HEALTH RISK ASSESSMENT

The HHRA will be focused on potential human health impacts associated with exposure to site-related contamination in the vicinity of the Lower Passaic River. The risk assessment will evaluate exposure to the COPCs identified through the screening process and will encompass all site-related exposure pathways and receptors identified in the PAR (Battelle, 2004a) and any additional ones subsequently identified throughout the project. A model will be used to estimate exposure concentrations. The risk assessment will be conducted following USEPA guidance, primarily USEPA's Risk Assessment Guidance for Superfund – Parts A, D, and E (USEPA 1989, 2001a, and 2001b, respectively) and other supplemental guidance referenced in the PAR (Battelle, 2004a). It will include the four steps that constitute the basic framework for all risk assessments, including:

- Data Review and Evaluation.
- Exposure Assessment.
- Toxicity Assessment.
- Risk Characterization.

8.3.1 Data Review and Evaluation

The first step of the risk assessment will be to review and evaluate the data gathered during the project for its completeness and usability in completing the baseline assessment, and to statistically summarize the data as necessary. The data review and evaluation will be conducted in accordance with the DQOs provided in the QAPP (MPI, 2005a) or the RI Reports. Ongoing assessment of data gathered will be made to refine the data collection program under the dynamic work plan approach so that the data generated during the field investigation in conjunction with usable historical data, will be sufficient to complete the risk assessment. However, the possibility exists that additional data generation may be required.

8.3.2 Exposure Assessment

The objective of the exposure assessment is to estimate the magnitude, frequency, duration, and routes of current and reasonably anticipated future human exposure to site-related constituents. As provided in the PAR (Battelle, 2004a), based on available information about current activities, as well as ongoing restoration initiatives, it has been assumed that human exposure to constituents in the river sediments would be associated with recreational activities such as swimming, wading, fishing, crabbing, and boating. Detailed descriptions of the receptors and types of exposures determined for this site to date are provided in the PAR (Battelle, 2004a), along with associated exposure parameter assumptions. The CSMs for human and ecological receptors developed based on existing data are provided in this WP as Figures 3-4 and 3-5, respectively. Human receptors identified for the site include a Recreational User and an Angler/Sportsman. In addition, a transient population has occasionally constructed temporary housing along the banks of the river; thus, a residential scenario also has been included in the CSM to address potential exposures to individuals in this type of community. The receptors and exposure scenarios associated with future use are not expected to differ significantly from those being evaluated under the current use scenarios. Consumption of fish and other aquatic organisms is anticipated to be the primary exposure pathway.

A more thorough analysis of the available data and supporting exposure assumptions (*i.e.*, a literature review to determine the need for an Angler-Creel survey) will be conducted to determine the need for collection of site-specific data in order to minimize the associated uncertainties in the risk assessment. Collection of specific data will follow the DQO process as described in the QAPP (MPI, 2005a) and will be provided in the FSP Volume 2 (in 2006). A model will be used to estimate exposure concentrations.

The exposure assessment outlined in the PAR (Battelle, 2004a) will be utilized in the risk assessment in addition to any additional information uncovered as the investigation progresses.

8.3.3 Toxicity Assessment

The toxicity assessment characterizes the relationship between the magnitude of exposure to a constituent and the nature and magnitude of adverse health effects that may result from each exposure. For purposes of risk assessment, adverse health effects are classified into two broad categories: noncarcinogenic and carcinogenic.

For this risk assessment, toxicity criteria will be selected according to the USEPA (2003a) OSWER Directive 9285.7-53 that recommends a hierarchy of human health toxicity values for use in risk assessments at Superfund sites. The hierarchy is as follows: (1) USEPA's Integrated Risk Information System (IRIS); (2) USEPA's (Office of Research and Development, National Center for Environmental Assessment, Superfund Health Risk Technical Support Center) Provisional Peer Reviewed Toxicity Values, and (3) other sources of information such as the California EPA's toxicity values and the

Agency for Toxic Substances Disease Registry (ATSDR) minimal risk levels (MRLs) for noncarcinogenic compounds.

8.3.4 Risk Characterization

Risk characterization involves combining the results of exposure assessment and the toxicity assessment to provide numerical estimates of potential human health risk. Risk characterization also considers the nature and weight of evidence supporting these risk estimates and the magnitude of uncertainty surrounding such estimates. In accordance with USEPA's guidelines for evaluating the potential toxicity of complex mixtures, the risk assessment will assume that the effects of all constituents are additive through a specific pathway within an exposure scenario (USEPA, 1986). Carcinogenic risks and noncarcinogenic hazards will be estimated using the methodology provided in the PAR (Battelle, 2004a).

8.4 ECOLOGICAL RISK ASSESSMENT

The objective of the ecological risk assessment process is to evaluate and characterize the potential for adverse effects to ecological receptors associated with exposure to COPECs present in environmental media of the Lower Passaic River. To evaluate these potential risks, ecological risk assessment (ERA) guidance from USEPA (1992, 1997) will be followed, which specifies a tiered process that encompasses eight steps. In the first tier, a screening-level ecological risk assessment (SLERA) will be conducted (encompassing Steps 1 and 2 of USEPA guidance) that includes development of a preliminary CSM, identification of COPECs, and a screening-level dose assessment using conservative assumptions. An initial site visit by the ecological risk assessors is also conducted at this time. The second tier or baseline ecological risk assessment (BERA) (Steps 3 through 7 of the USEPA process) uses the output from the SLERA to refine the problem formulation and further evaluate any COPECs that may cause an adverse effect to receptors of concern. Exposure and effects will be assessed for all endpoints defined in the problem formulation step and used to characterize risks to ecological receptors. The risk management decision process (Step 8) is conducted by the USEPA ecological risk manager, who determines what (if any) remedial actions are necessary. The USEPA process also specifies a number of Scientific Management

Decision Points (SMDPs) where the project team reviews the status of the BERA with the USEPA ecological risk manager and, if necessary, determine appropriate future courses of action (USEPA, 1997).

Based on an evaluation of the likely food web for the Lower Passaic River, complete ecological exposure routes for higher-trophic level organisms are likely to be associated with ingestion of contaminated prey, particularly benthic invertebrates and fish, and direct/incidental ingestion of sediment and (to a lesser extent) surface water. For the purposes of future assessment of risk to ecological receptors, these will be considered the primary routes of exposures for mammals and birds in the Lower Passaic River. Direct contact with sediments will likely be a primary route of exposure for plants, invertebrates, and fish receptors.

Assuming that the SLERA does not determine that sufficient information is available to conclude that ecological risks associated with the Lower Passaic River are low or non-existent, the site will move toward a BERA. The BERA will expand on particular ecological concerns at the site, following input from stakeholders and other involved parties. In the SLERA, conservative assumptions would be used where site-specific information was lacking. The BERA, however, would be more specific and encompass new data compiled during subsequent site investigations (*e.g.*, tissue concentrations, community studies, and toxicity data). Although it is premature to describe specific aspects of the BERA, the assessment will include the following components: Problem Formulation (Step 3), Study Design and Verification of Field Sampling Design (Steps 4 and 5), Site Investigation and Data Analysis (Step 6), and Risk Characterization (Step 7).

8.4.1 Problem Formulation (Step 3)

The PAR (Battelle, 2004a) presented a preliminary CSM and identified ecological receptors of concern, potential exposure pathways, and COPECs. Following the review of additional data collected as part of FSP Volume 1 (MPI, 2005b) field activities planned for 2005, each of these BERA components will be reassessed based on current understanding of site conditions, and revised if necessary.

The overall goals of the BERA will also be established during the problem formulation phase. Assessment endpoints are expressed in terms of valued social and important ecological attributes; examples of assessment endpoints include (1) reproduction of piscivorous (fish-eating) birds, and (2) survival of benthic invertebrate communities. Following the selection of the BERA assessment endpoints, the risk questions and measurement endpoints presented in the PAR will be revised as necessary. It is likely that measurement endpoints will include community surveys (fish, epibenthic/benthic macroinvertebrate communities), bioassays, and evaluation of tissue residue data.

8.4.2 Study Design and Data Quality Objectives Process and Verification of Field Study Design (Steps 4 & 5)

Following finalization of the CSM and selection of assessment and measurement endpoints, a statistically-based study design will be developed as part of the overall project DQO process so that information necessary to conduct the BERA as efficiently as possible is collected. As part of Step 4, a WP Addendum will be prepared to document the decisions made in Steps 1 through 3 as well as identifying additional tasks necessary to complete the BERA. In addition, the specification of and proposed collection methodologies for any additional ecological data requirements will be provided in Volume 2 of the FSP. In addition, the QAPP (MPI, 2005a) will be revised as necessary. In accordance with Step 5 of the USEPA process, the practicality of the proposed ecological studies will be confirmed in the field, prior to implementation of the study. In addition, the appropriateness of preliminarily identified reference areas will be confirmed.

8.4.3 Site Investigation and Data Analysis (Step 6)

Following execution of the FSP Volume 2 (in 2006) during the site investigation phase, the BERA will proceed with analysis of both ecological exposures and effects in Step 6. The exposure analysis will determine the extent to which ecological receptors are exposed to COPECs both spatially and temporally. Analytical data, which are determined to be of suitable quality for risk assessment purposes [as specified in the QAPP (MPI, 2005a)], will be statistically summarized in order to estimate ecological exposures. In addition, it is likely that mathematical models will be used to estimate the trophic transfer of COPECs through the food web. For each receptor of concern, the ecological effects analysis will describe the relationship between exposure to the individual COPECs and adverse ecological responses pertinent to the selected assessment endpoints.

8.4.4 Risk Characterization (Step 7)

Risk Characterization is the final step in the risk assessment process. During this step, risks are estimated by combining the results of the exposure and effects analysis, and interpreted relative to the selected assessment endpoints. An evaluation of BERA uncertainties will also be conducted to aid the ecological risk manager during the remedial decision-making process.

9.0 PROJECT SCHEDULE

A summary of the overall project schedule is provided below in Table 9-1.

Table 9-1: LPRRP Project Schedule

PROJECT ACTIVITY	DATE
Bathymetry Survey	October 2004
Historical Geochemical Data Evaluation	April 2005
Geophysical Survey	April 2005
Hydrodynamic Survey	July 2004 – September 2005
Sediment Investigations	Spring 2005 – Fall 2005
Water Quality Investigation	Summer 2005 – Fall 2005
Biological Investigations	Spring 2006 – Fall 2006
Candidate Restoration Site Screening	Spring 2004 – Spring 2005
Dredging and Decontamination Pilots	Fall 2005
Model Calibration	Spring 2005 – Spring 2008
Baseline Modeling	Fall 2007 – Winter 2009
Risk Assessment Pathways Analysis Report	May 2005
Baseline Risk Assessments	Winter 2006 – Winter 2009
Draft Feasibility Study	August 2010
Final Feasibility Study	September 2011
Select Remedial and Restoration Plan (Record of Decision)	March 2012

10.0 ACRONYMS

2,4-D	2,4-Dichlorophenoxyacetic acid
2,4,5-T	(2,4,5-Trichlorophenoxy)acetic acid
AOC	Administrative Order of Consent
APE	Area of Potential Effect
ARAR	Applicable or Relevant and Appropriate Requirements
ASCII	American Standard Code for Information Interchange
ATSDR	Agency for Toxic Substance Disease Registry
BASF	Badische Anilin- & Soda-Fabrik, AG
BAZ	Biologically Active Zone
Be-7	Beryllium 7
BERA	Baseline Ecological Risk Assessment
BOD	Biochemical Oxygen Demand
CARP	Contamination Assessment and Reduction Project
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfs	Cubic Feet per Second
CLH	Chemical Land Holdings
CLP	Contract Laboratory Program
cm	centimeter
COPC	Chemical of Potential Concern
COPEC	Chemical of Potential Ecological Concern
CSM	Conceptual Site Model
CSO	Combined Sewer Overflow
CTD	Conductivity, Temperature, and Depth
DDT	4-4'-Dichlorodiphenyltrichloroethane
.DGN	indicates a Bentley MicroStation Design File
DO	Dissolved Oxygen
DPT	Direct Push Technology
DQO	Data Quality Objective
EDD	Electronic Data Deliverable
EIS	Environmental Impact Statement
EPW	Evaluation for Planned Wetlands
ERA	Ecological Risk Assessment
ER-L	Effects Range Low
ER-M	Effects Range Median
ETM	Estuarine Turbidity Maximum
^{o}F	Degrees Fahrenheit
FDEP	Florida Department of Environmental Protection
FS	Feasibility Study
FSP	Field Sampling Plan
ft^3/s	cubic feet per second
GIS	Geographical Information System
HGM	Hydrogeomorphic Approach
HHRA	Human Health Risk Assessment
HMW	High Molecular Weight

HTRW	Hazardous, Toxic, and Radioactive Waste
IRIS	Integrated Risk Information System
LER	Lands, Easements, and Rights-of-Way
LMW	Low Molecular Weight
MEDD	Multi-Media Electronic Data Deliverable
MHW	Meah High Water
MLW	Mean Low Water
MNR	Monitored Natural Recovery
MOA	Memorandum of Agreement
mph	Miles per Hour
MPI	Malcolm Pirnie, Inc.
MRL	Minimal Risk Level
MSL	Mean Sea Level
N/m^2	Newtons per square meter
NAWQC	National Ambient Water Quality Criteria
NCP	National Contingency Plan
NEPA	National Environmental Policy Act
NGVD29	National Geodetic Vertical Datum of 1929
NOAA	National Oceanic and Atmospheric Administration
NJ	New Jersey
NJADN	New Jersey Atmospheric Deposition Network
NJDEP	New Jersey Department of Environmental Protection
NJDOT	New Jersey Department of Transportation
NJDOT-OMR	New Jersey Department of Transportation – Office of Maritime Resources
NPDES	National Pollutant Discharge Elimination System
NPL	National Priority List
NRC	National Research Council
NRHP	National Register of Historical Places
NRDA	Natural Resource Damage Assessment
NTDE	National Tide Datum Epoch
NY	New York
NYSDEC	New York State Department of Environmental Conservation
NYSDOH	New York State Department of Health
OBS	Optical Backscatter
OCC	Occidental Chemical Company
ORNL	Oak Ridge National Laboratory
OU	Operable Unit
Pa	Pascal
PAH	Polycyclic Aromatic Hydrocarbon
PAR	Pathways Analysis Report
Pb-210	Lead-210
PCB	Polychlorinated Biphenyl
PCDD	Polychlorinated dibenzo-p-dioxins
PES	Particle Entrainment Simulator
PMP	Project Management Plan
POTW	Publicly Owned Treatment Works
ppb	parts per billion
ppm	parts per million

ppt	parts per trillion
PREmis	Passaic River Estuary Management Information System
PRG	Preliminary Remediation Goal
PRP	Potentially Responsible Party
PRSA	Passaic River Study Area
PSE&G	Public Service Electric and Gas Company
PVSC	Passaic Valley Sewerage Commissioners
QAPP	Quality Assurance Project Plan
QA/QC	Quality Assurance/Quality Control
RCRA	Resource Conservation Recovery Act
REP	Real Estate Plan
RI	Remedial Investigation
RM	River Mile
SAV	Submerged Aquatic Vegetation
SHPO	State Historical Preservation Officer
SLERA	Screening Level Ecological Risk Assessment
SMDP	Scientific Management Decision Point
SPI	Sediment Profile Imagery
SQG	Sediment Quality Guideline
SQO	Site Quality Control Officer
SSS	Side-Scan Sonar
SVOC	Semi-Volatile Organic Compound
TAMS	TAMS/EarthTech, Inc.
TCDD	Tetrachlorodibenzo-p-dioxin
TEPH	Total Extractable Petroleum Hydrocarbon
Th-234	Thorium-234
TKN	Total Kjeldahl Nitrogen
TOC	Total Organic Carbon
TMDL	Total Maximum Daily Load
TPH	Total Petroleum Hydrocarbon
TSI	Tierra Solutions, Inc.
TSS	Total Suspended Solids
TVGA	Tallamy, Van Kuren, Gertia, and Associates
USACE	U.S. Army Corps of Engineers
USEPA	U.S. Environmental Protection Agency
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VOC	Volatile Organic Compound
WP	Work Plan
WRDA	Water Resources Development Act

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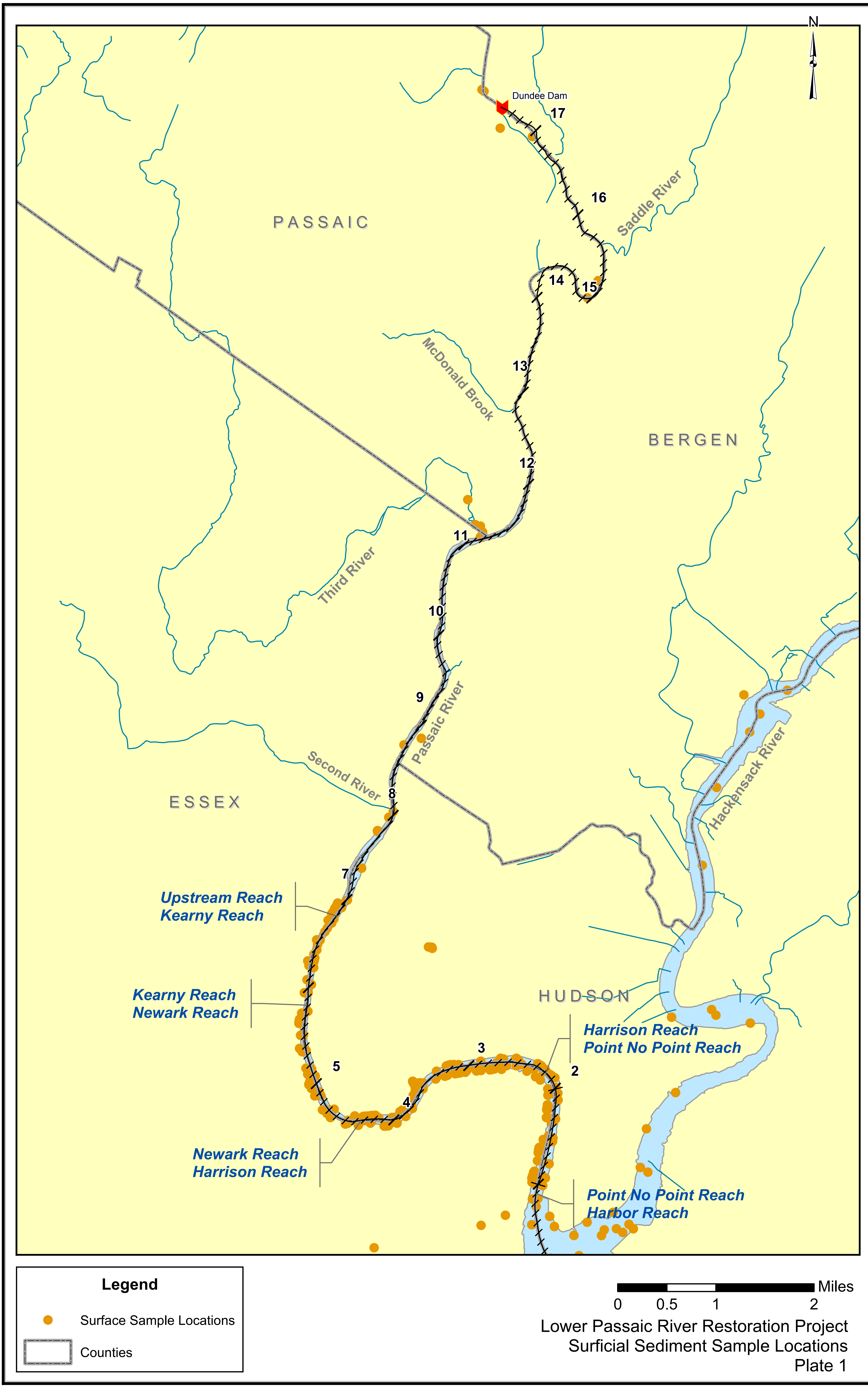
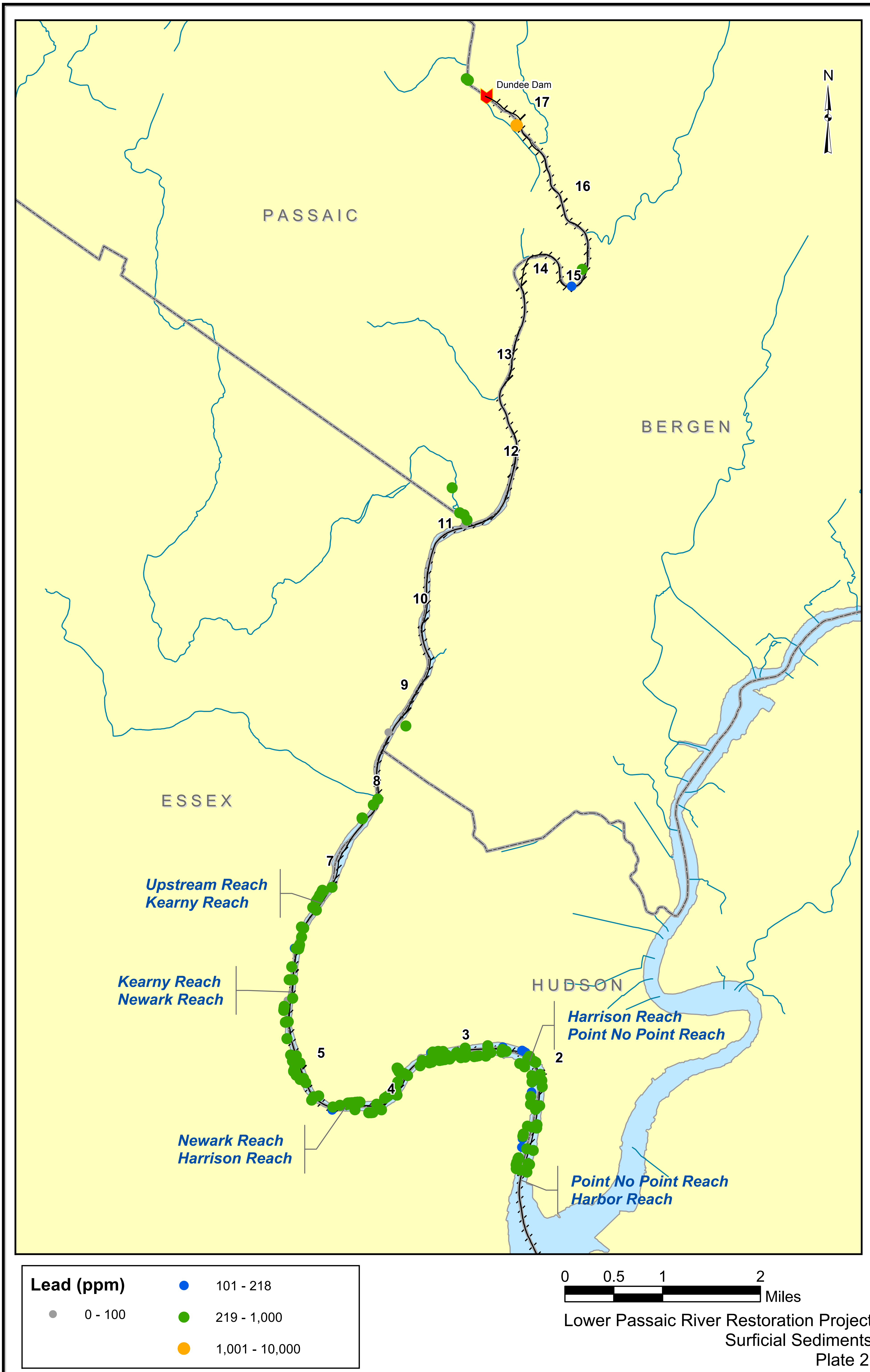
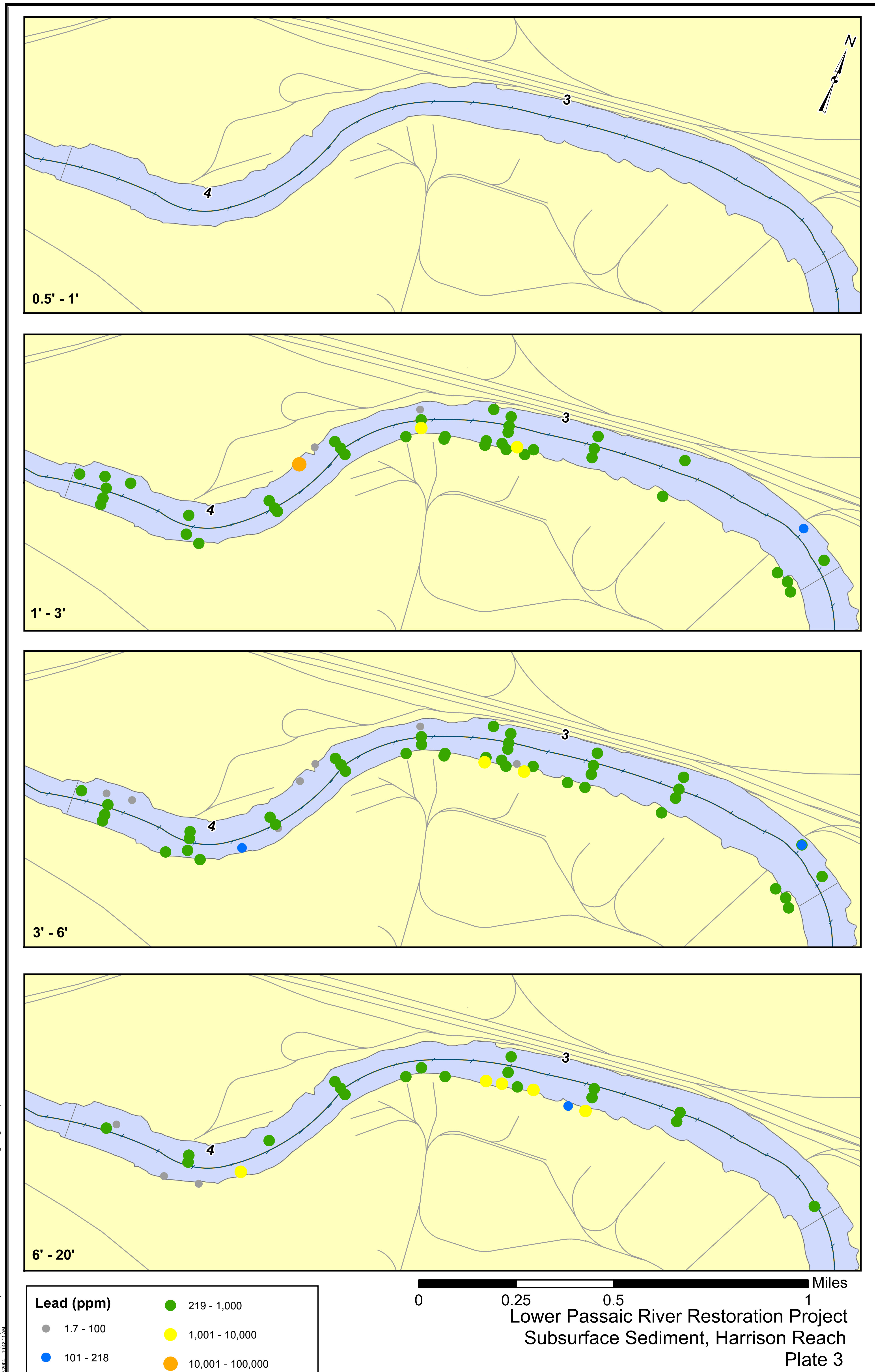
PLATES



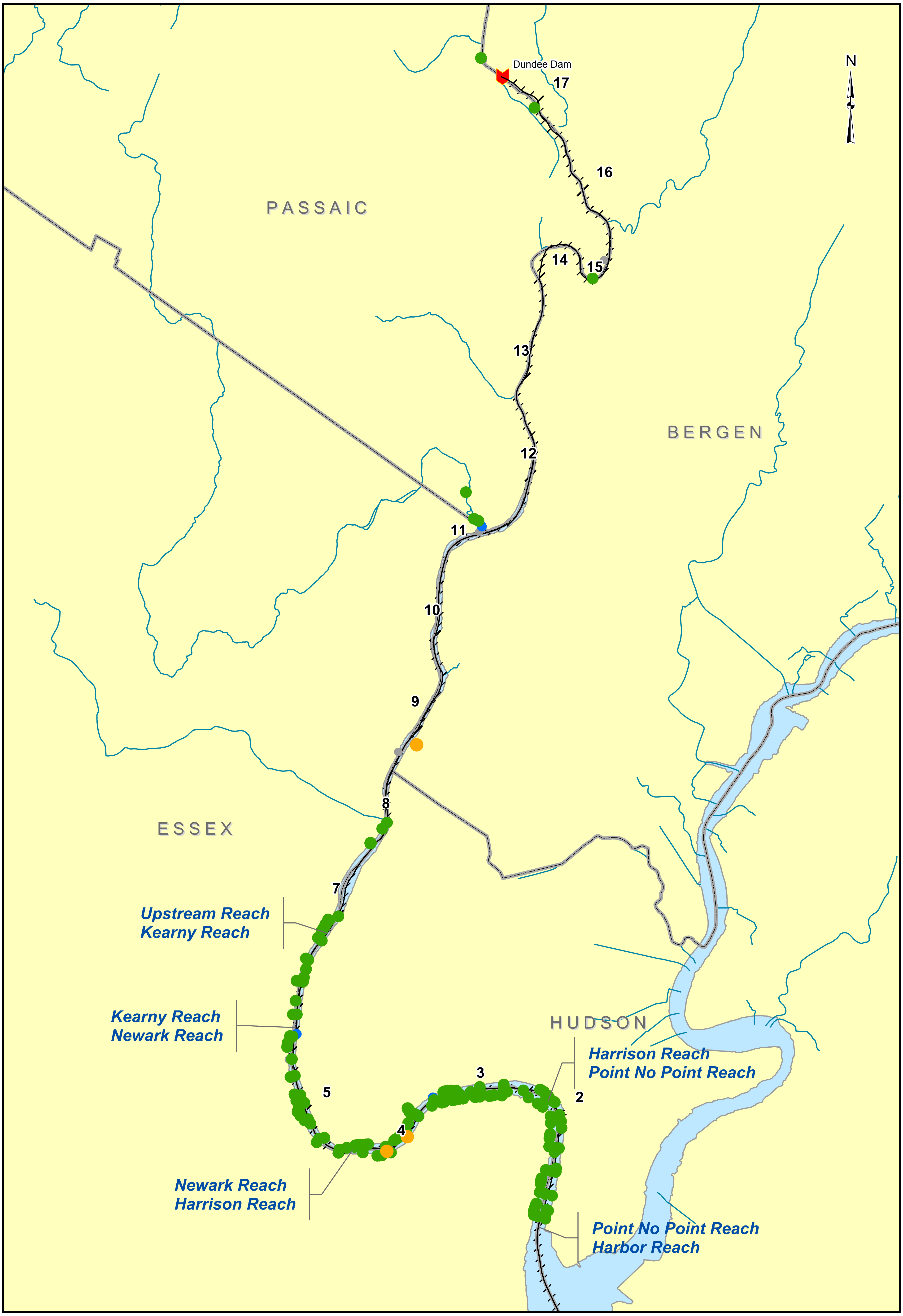
Lower Passaic River Restoration Project
Surficial Sediment Sample Locations
Plate 1



Lower Passaic River Restoration Project
Surficial Sediments
Plate 2



Lower Passaic River Restoration Project
Subsurface Sediment, Harrison Reach
Plate 3

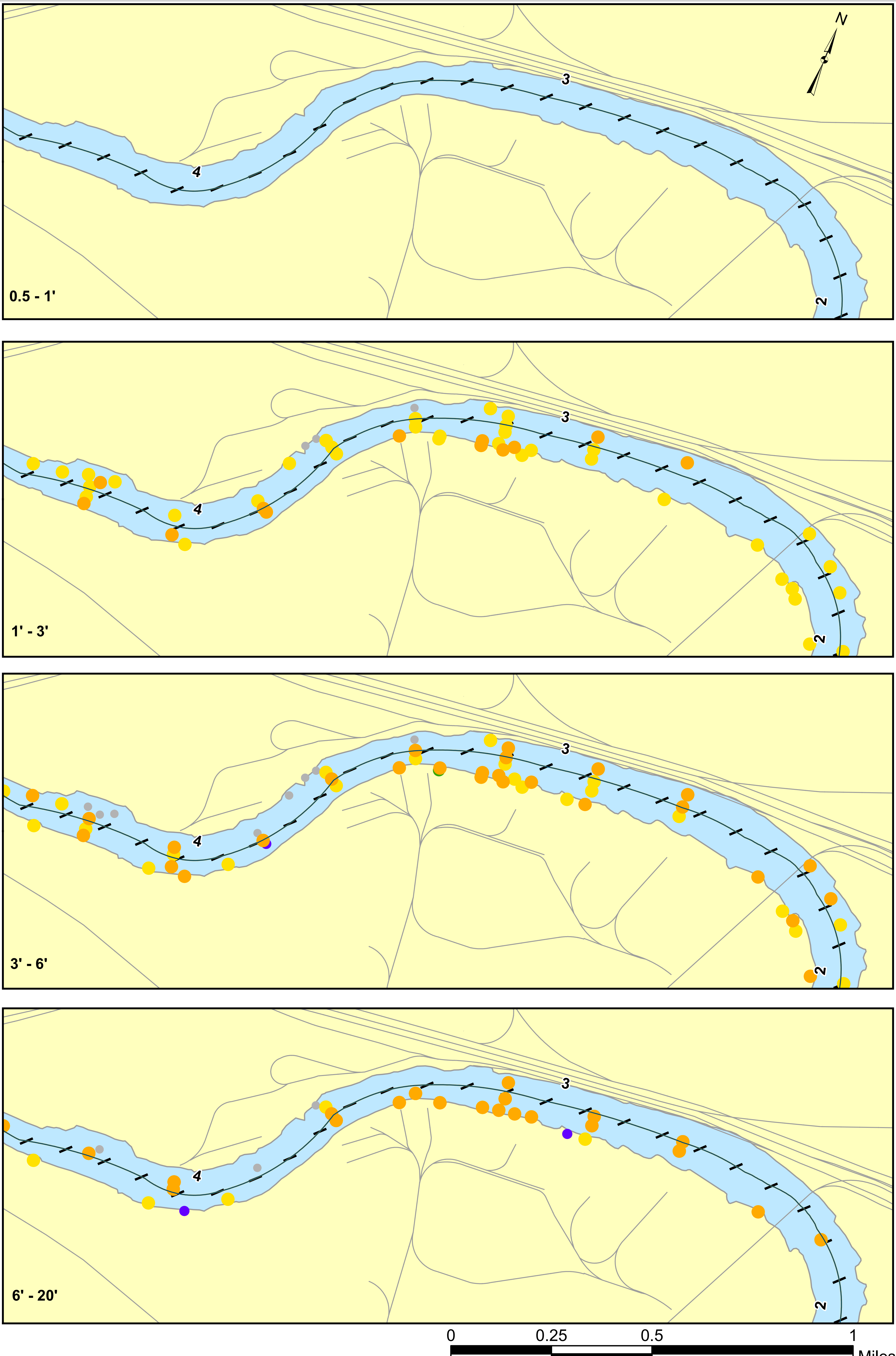


Mercury (ppm)

- 0 - 0.710
- 0.711 - 1
- 1.001 - 10
- 10.001 - 100

0 0.5 1 2 Miles

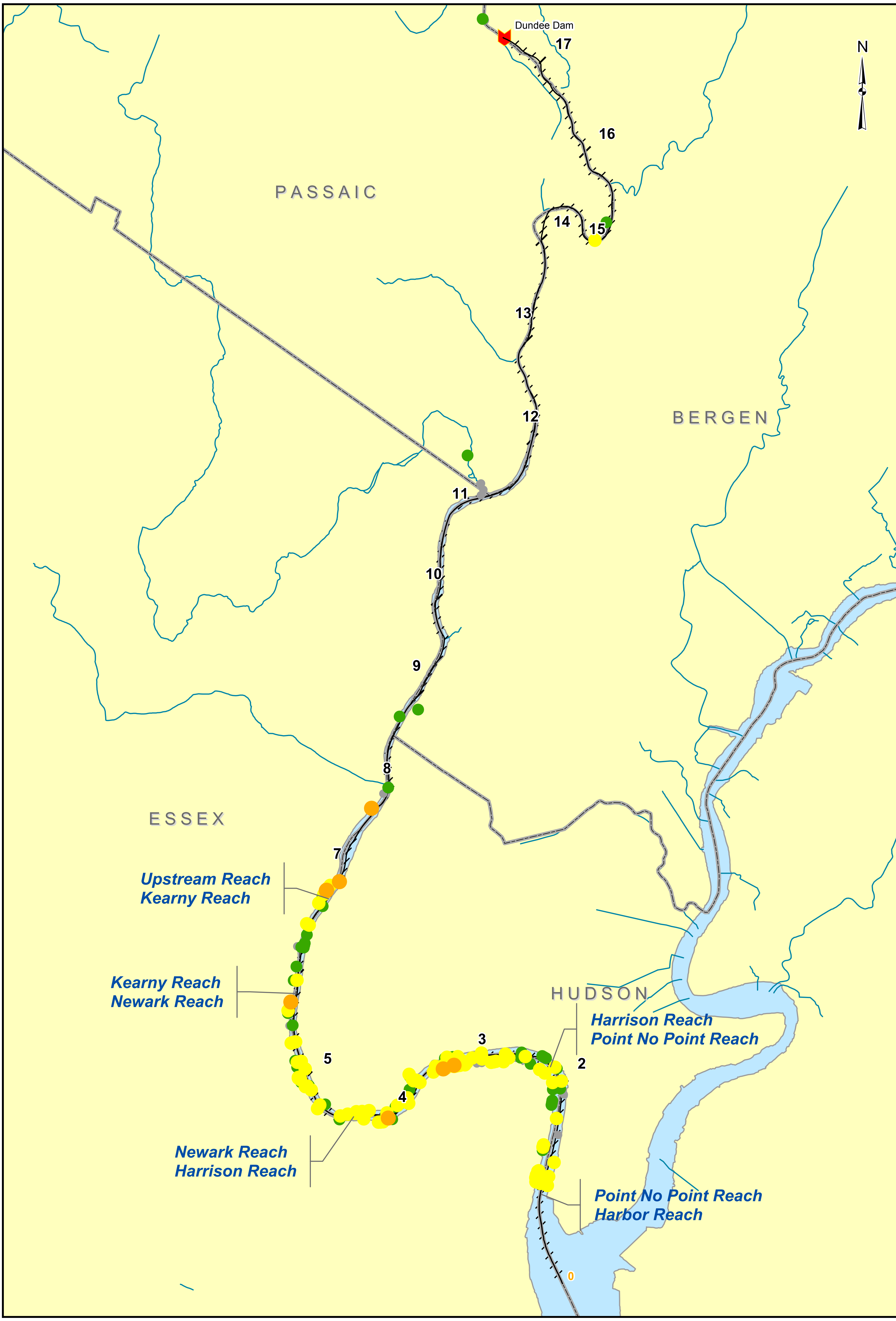
Lower Passaic River Restoration Project
Surficial Sediments
Plate 4



Mercury (ppm)

- 0 - 0.100
- 0.101 - 0.710
- 0.711 - 1
- 1.001 - 10
- 10.001 - 30

Lower Passaic River Restoration Project
Subsurface Sediment, Harrison Reach
Plate 5

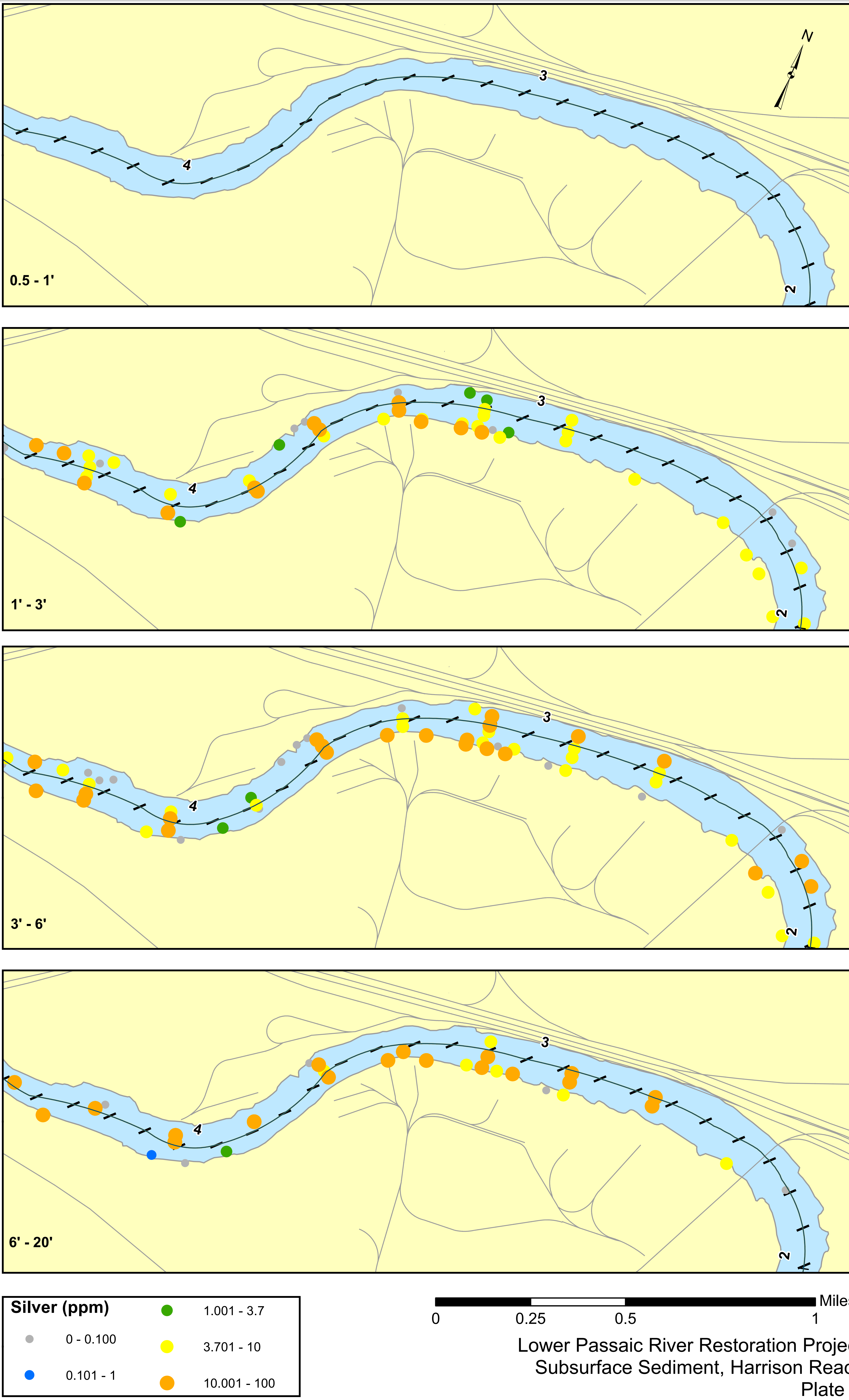


Silver (ppm)

- 0 - 0.100
- 0.101 -1.000
- 1.001 - 3.700
- 3.701 - 10
- 10.001 - 100

0 0.5 1 2 Miles

Lower Passaic River Restoration Project
Surficial Sediments
Plate 6



Lower Passaic River Restoration Project
Subsurface Sediment, Harrison Reach
Plate 7

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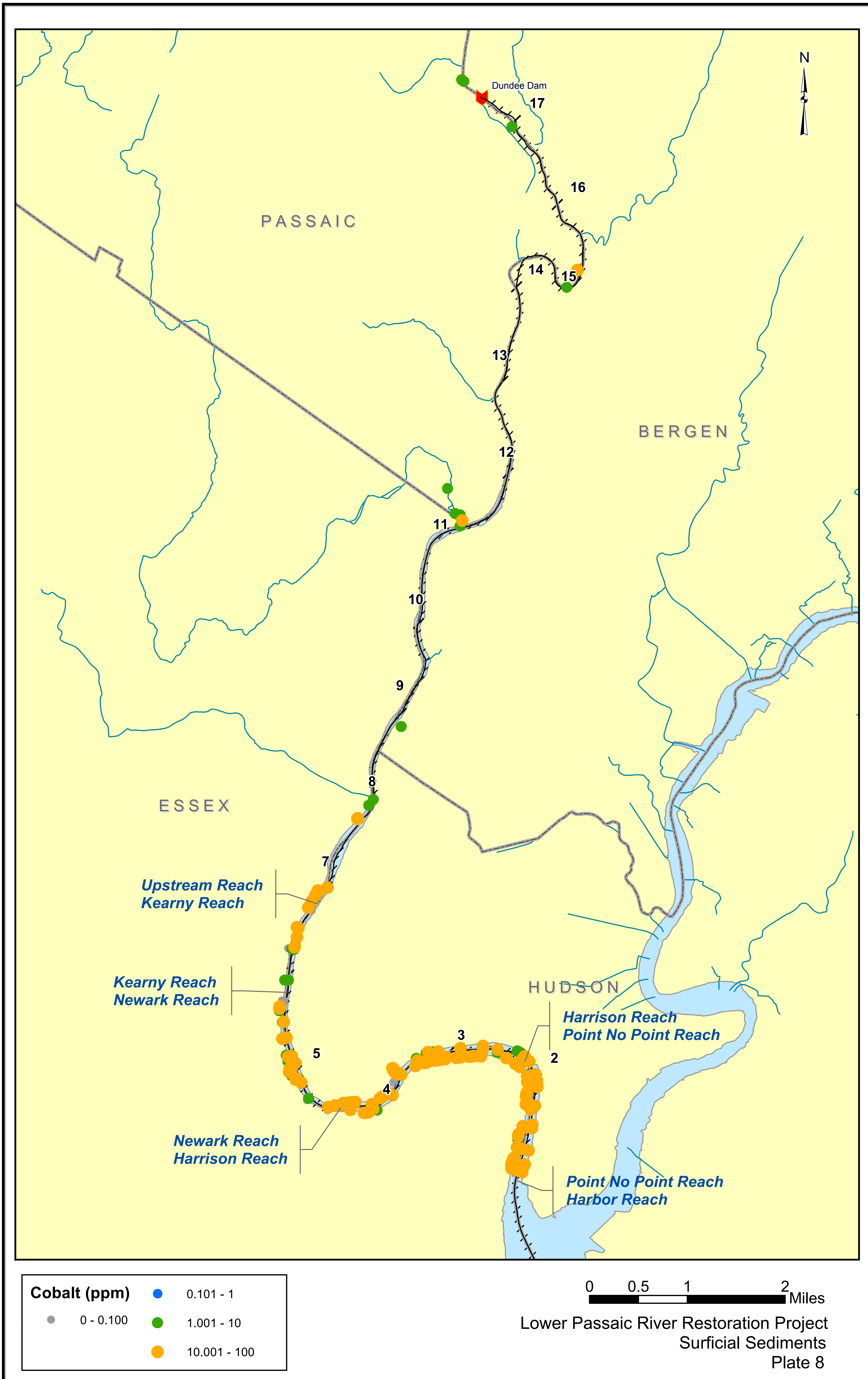
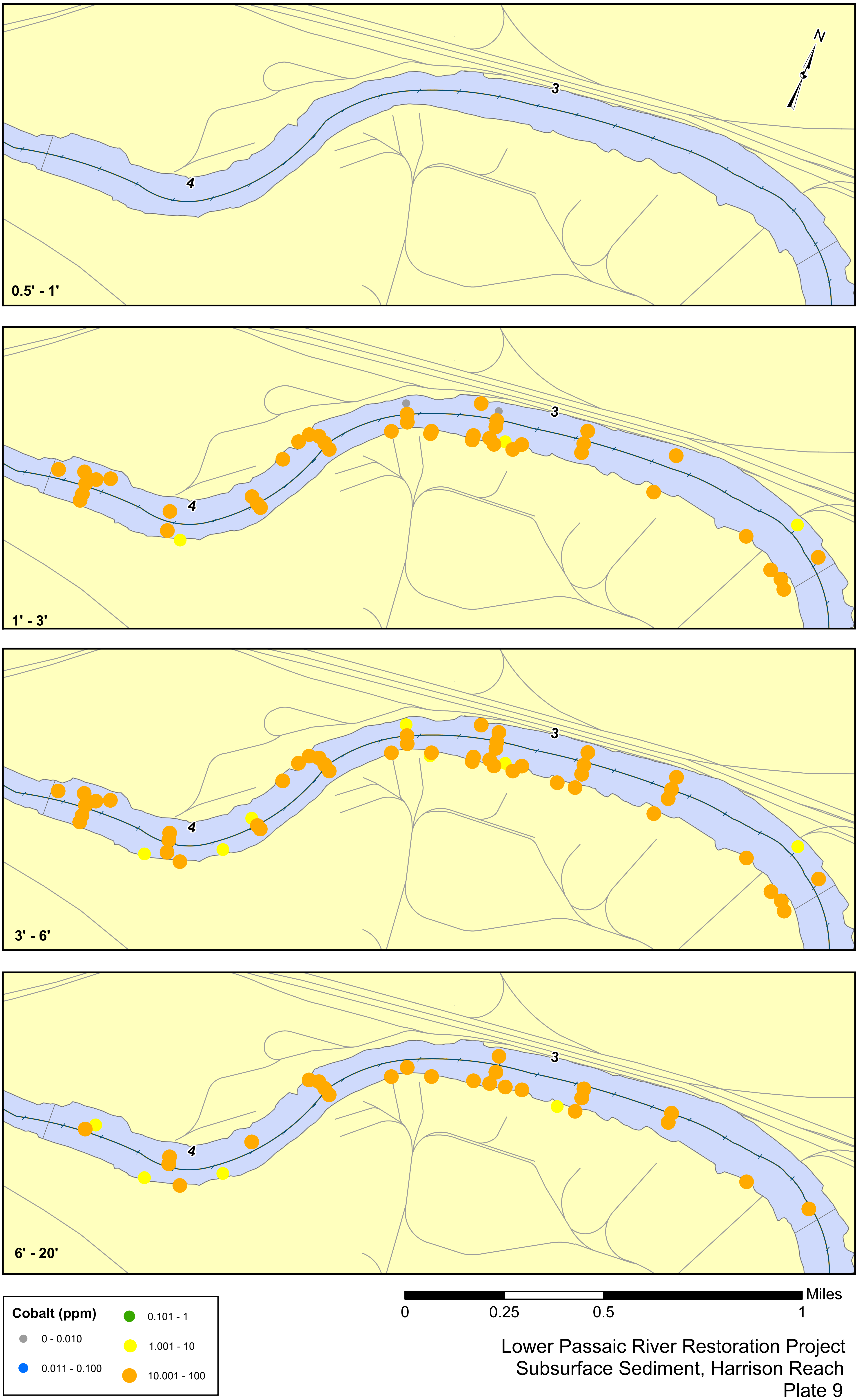
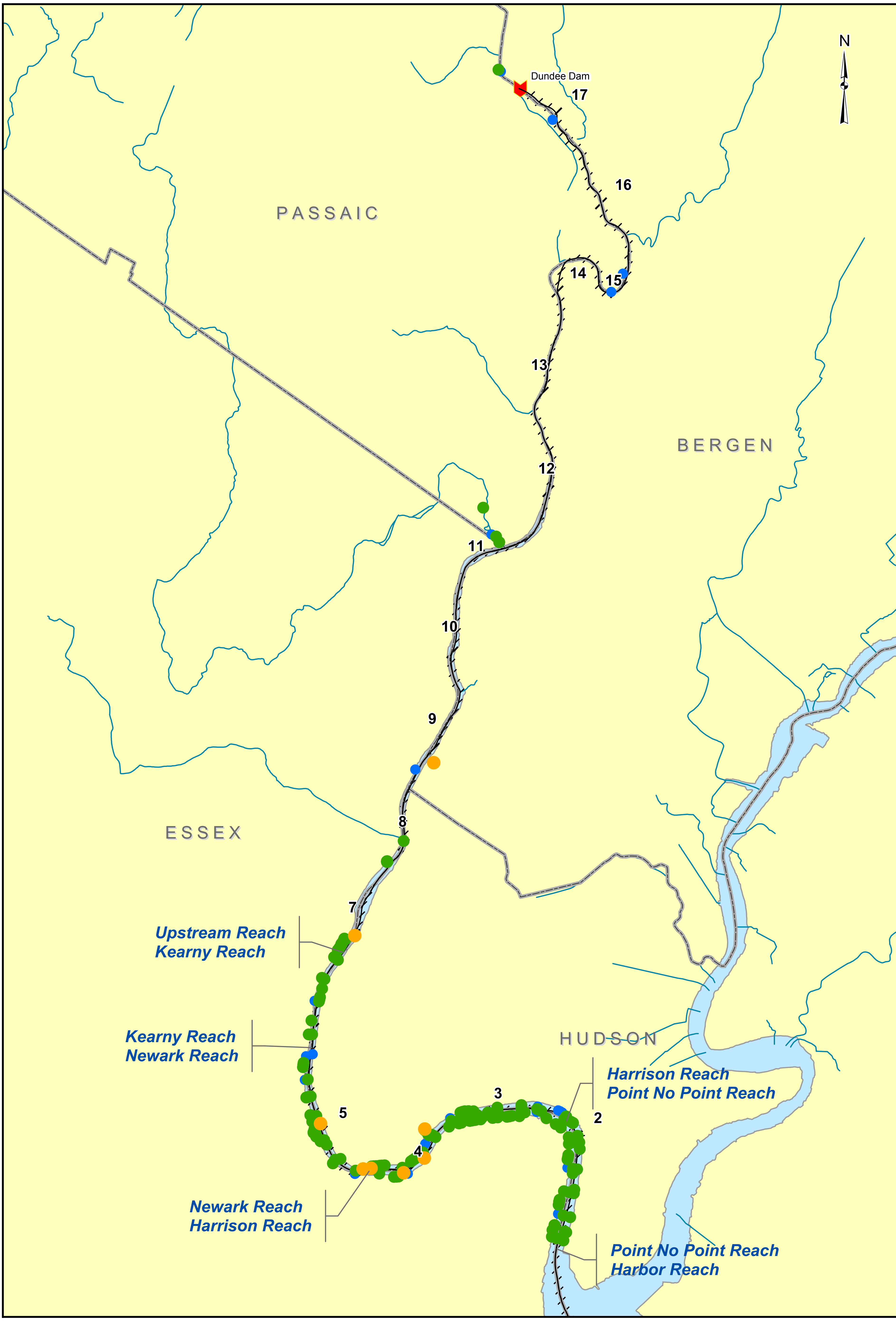

Dundee Dam
N
17
16
15
14
13
12
11
10
9
8
7
5
4
3
2
PASSAIC
BERGEN
ESSEX
HUDSON
Upstream Reach
Kearny Reach
Kearny Reach
Newark Reach
Newark Reach
Harrison Reach
Harrison Reach
Point No Point Reach
Point No Point Reach
Harbor Reach
Cobalt (ppm)
0 - 0.100
0.101 - 1
1.001 - 10
10.001 - 100
0 0.5 1 2 Miles
Lower Passaic River Restoration Project
Surficial Sediments
Plate 8



Lower Passaic River Restoration Project
Subsurface Sediment, Harrison Reach
Plate 9

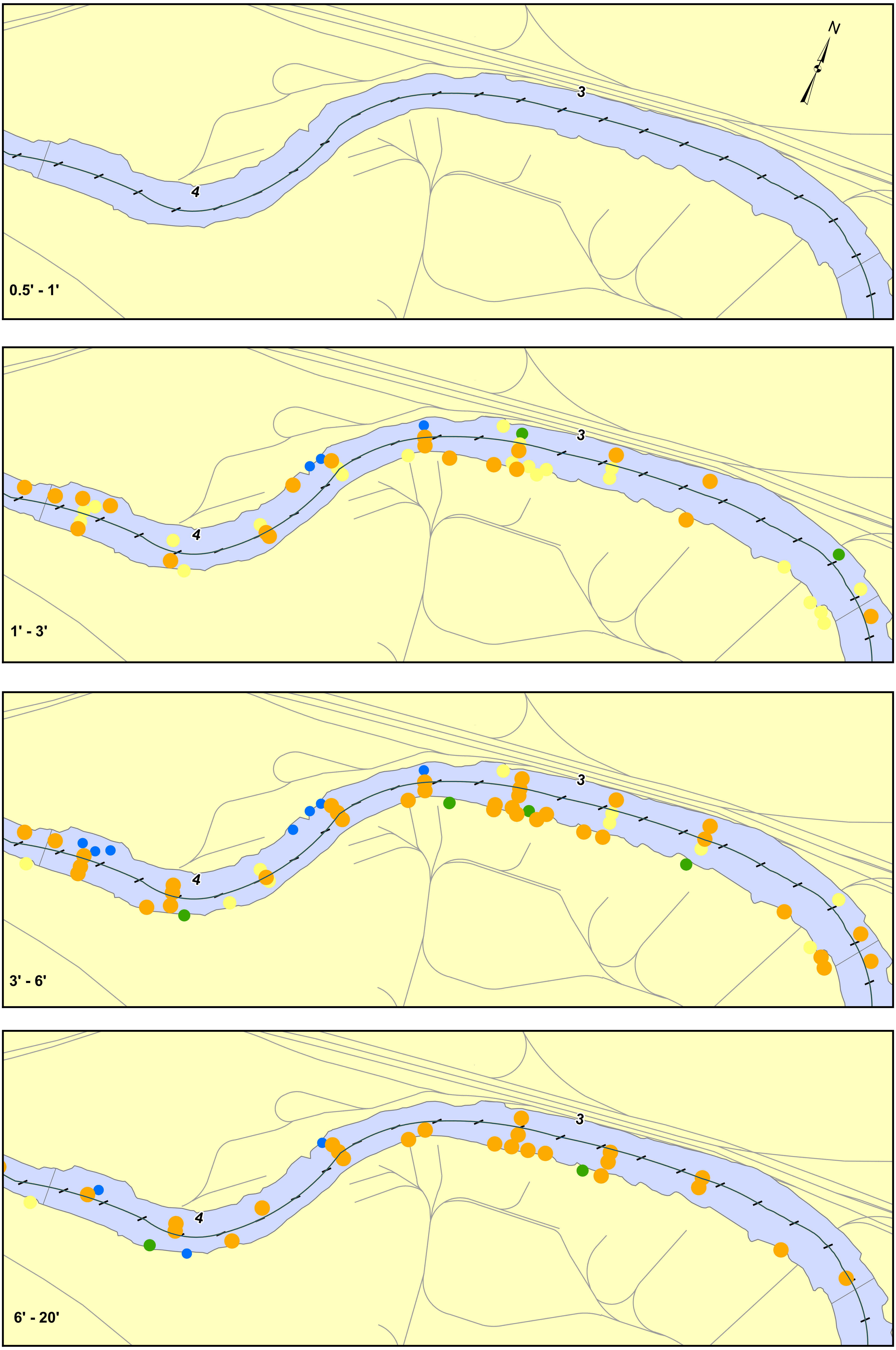


Zinc (ppm)

- 0.001 - 100
- 101 - 410
- 411 - 1,000
- 1,001 - 10,000

Miles: 0, 0.5, 1, 2

Lower Passaic River Restoration Project
Surficial Sediments
Plate 10

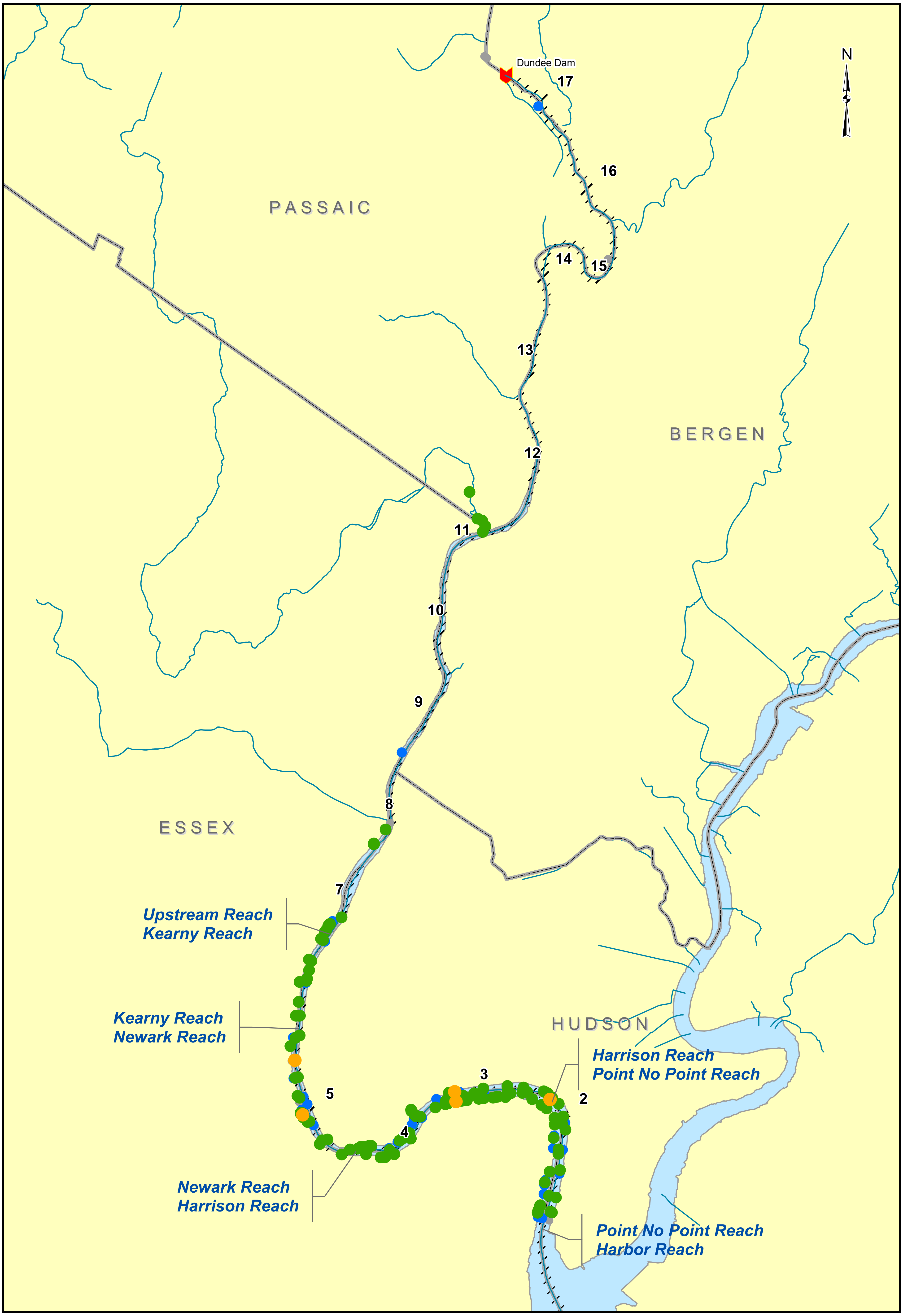


Zinc (ppm)

- 14.9 - 100
- 101 - 410
- 411 - 1,000
- 1,001 - 10,000

Miles: 0 0.25 0.5 1

Lower Passaic River Restoration Project
Subsurface Sediment, Harrison Reach
Plate 11

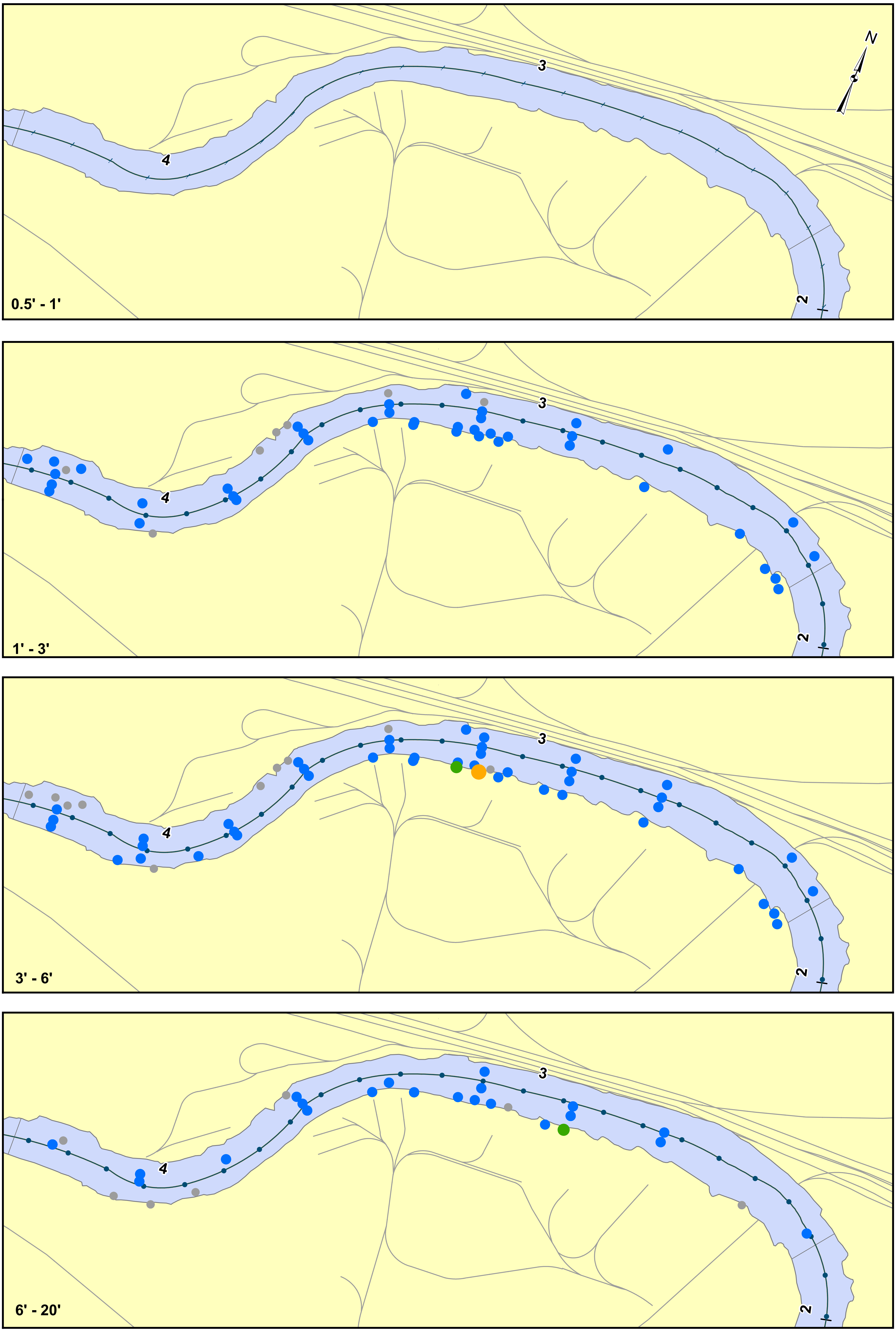


Total DDT (ppb)

- 0 - 46
- 47 - 100
- 101 - 1,000
- 1,001 - 10,000

0 0.5 1 2 Miles

Lower Passaic River Restoration Project
Surficial Sediments
Plate 12

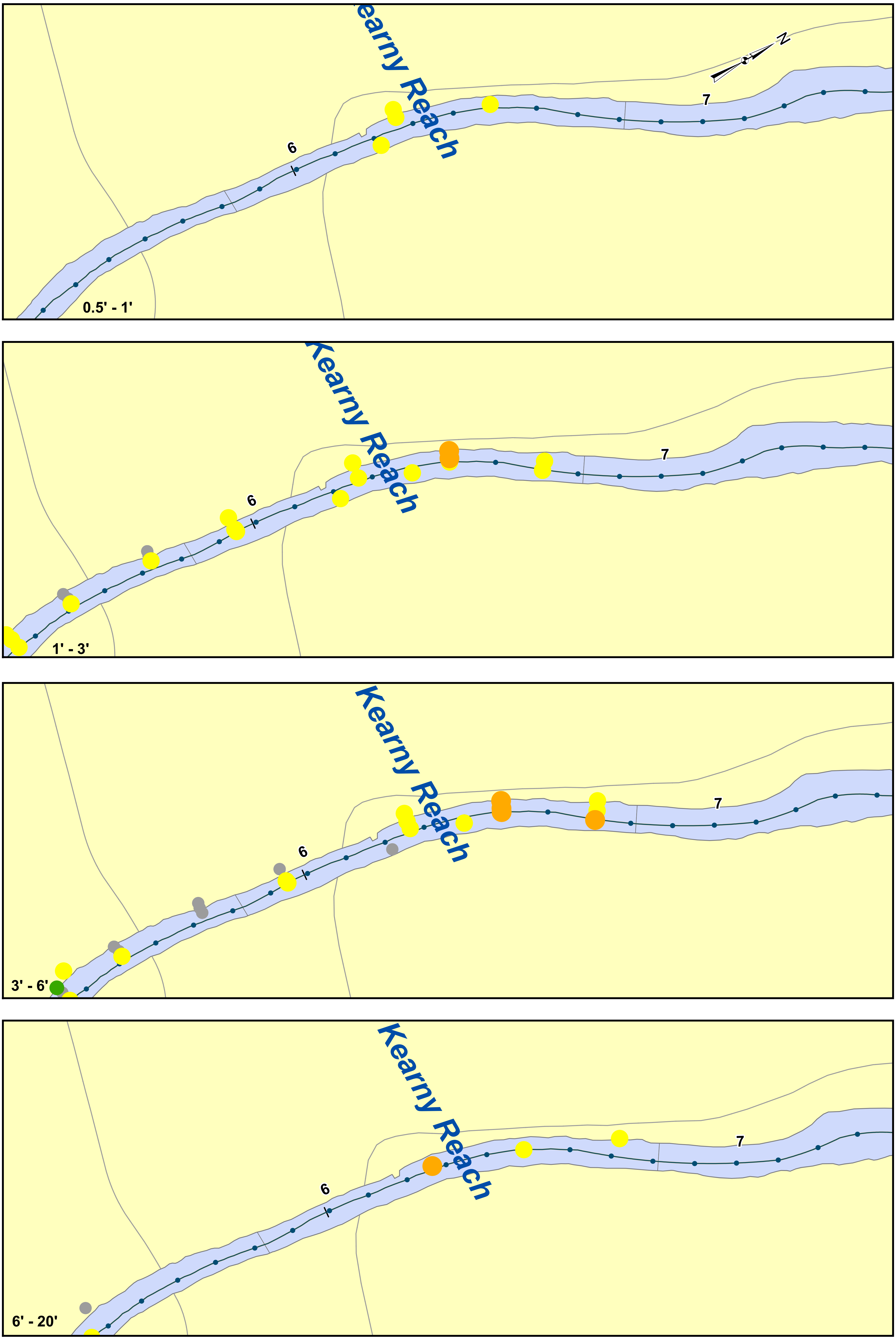


0 0.25 0.5 1 Miles

Total DDT (ppb)

- 0 - 46
- 46 - 100,000
- 100,000 - 1,000,000
- 1,000,000 - 10,000,000
- 10,000,000 - 100,000,000

Lower Passaic River Restoration Project
Subsurface Sediment, Harrison Reach
Plate 13

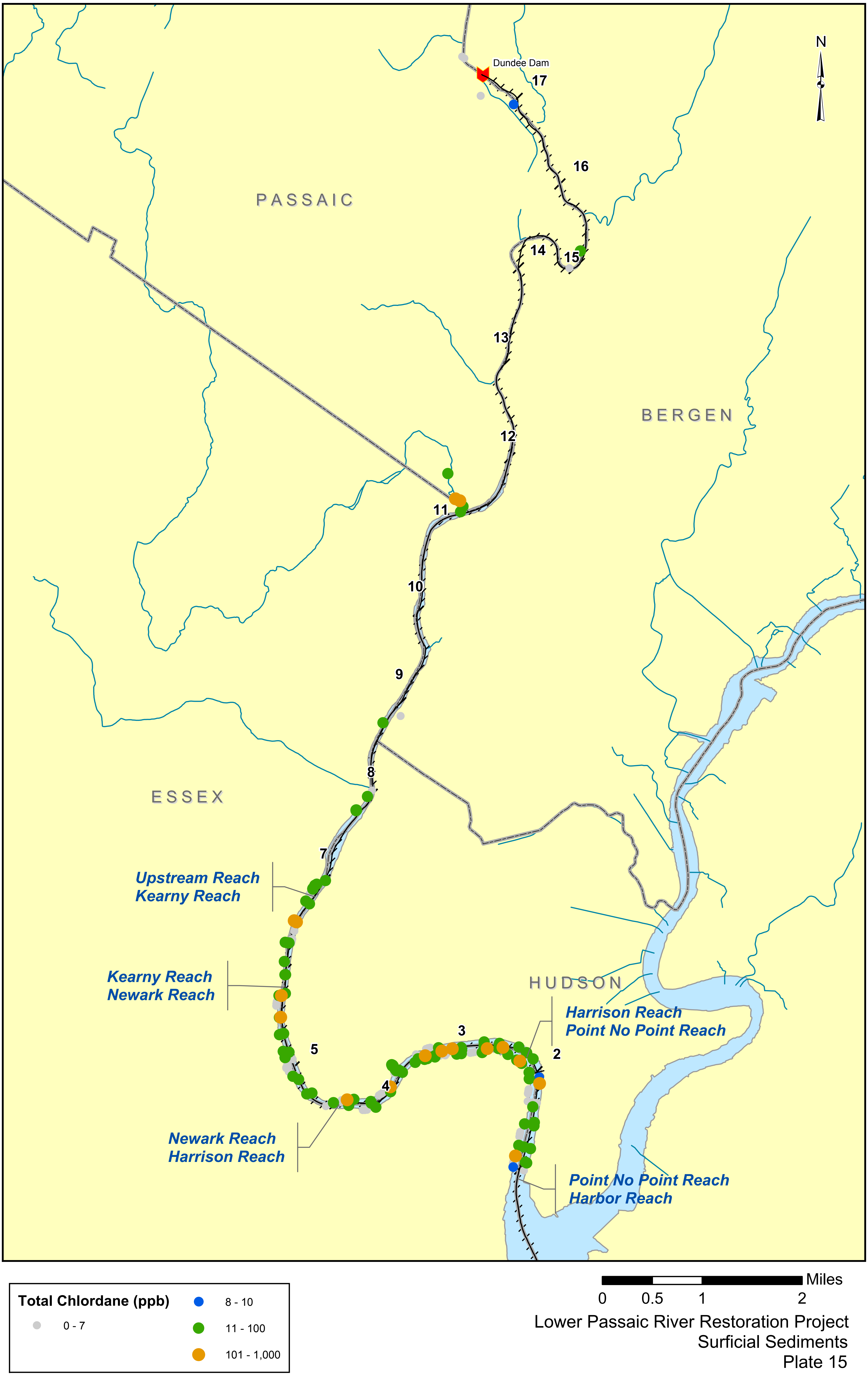


Total DDT (ppb)

- 0 - 46
- 47 - 100
- 101 - 1,000
- 1,001 - 10,000

0 | 0.25 | 0.5 | 1 Miles

Lower Passaic River Restoration Project
Subsurface Sediment, Newark & Kearny Reaches
Plate 14



Lower Passaic River Restoration Project
Surficial Sediments
Plate 15

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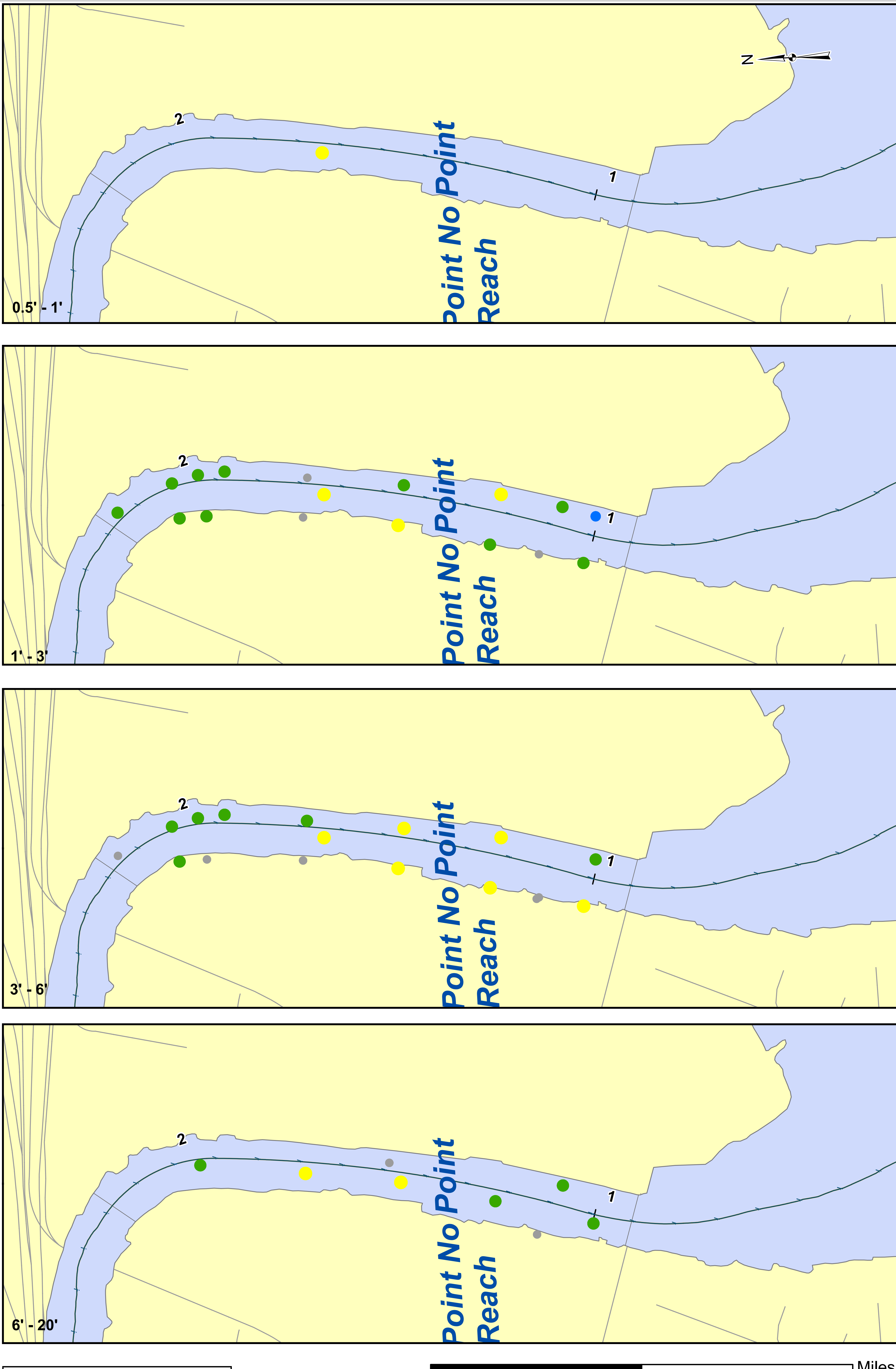
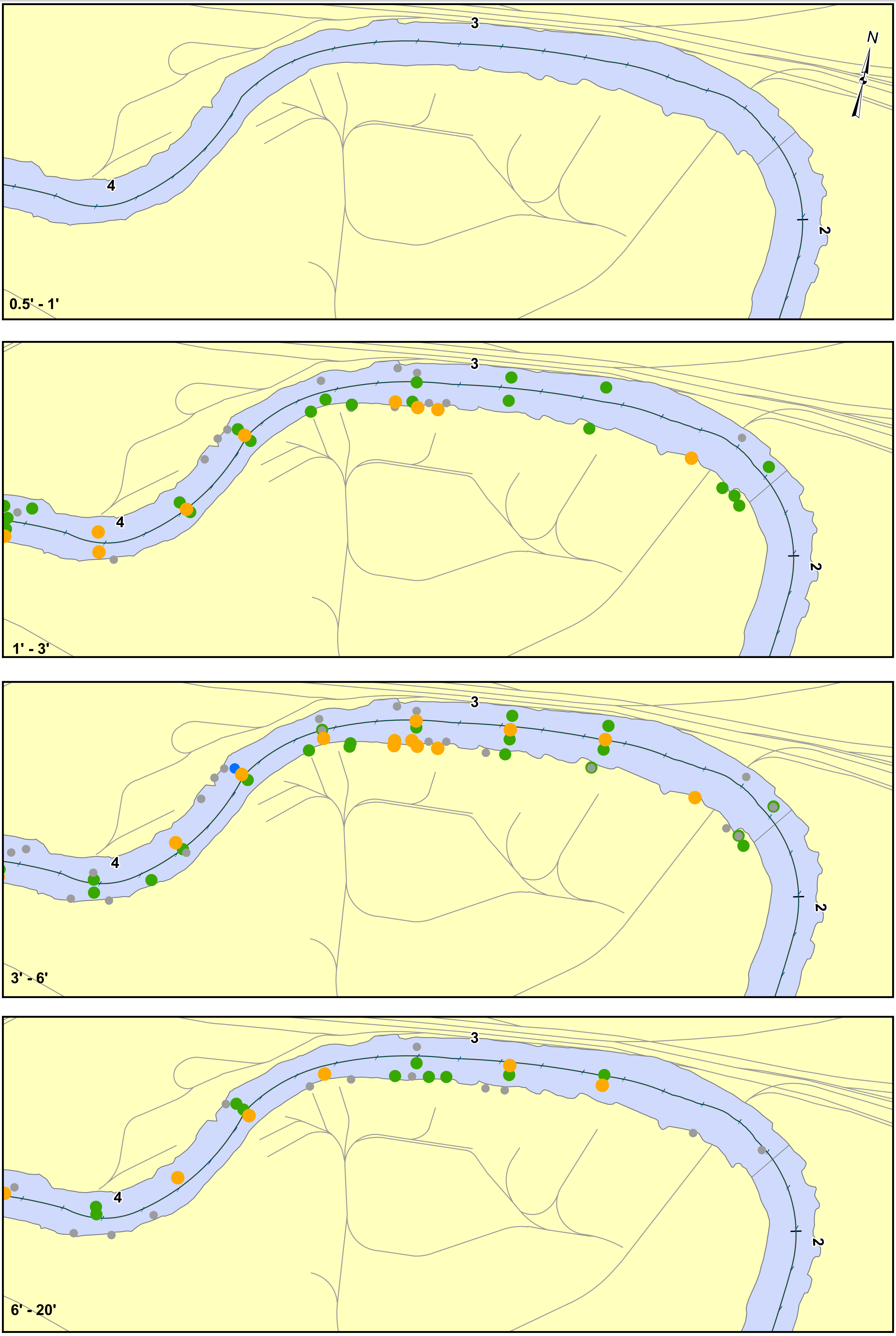


Legend

Total Chlordane (ppb)

- 0 - 7
- 7 - 10
- 10 - 100
- 100 - 1,000

Lower Passaic River Restoration Project
Subsurface Sediment, Point No Point Reach
Plate 16

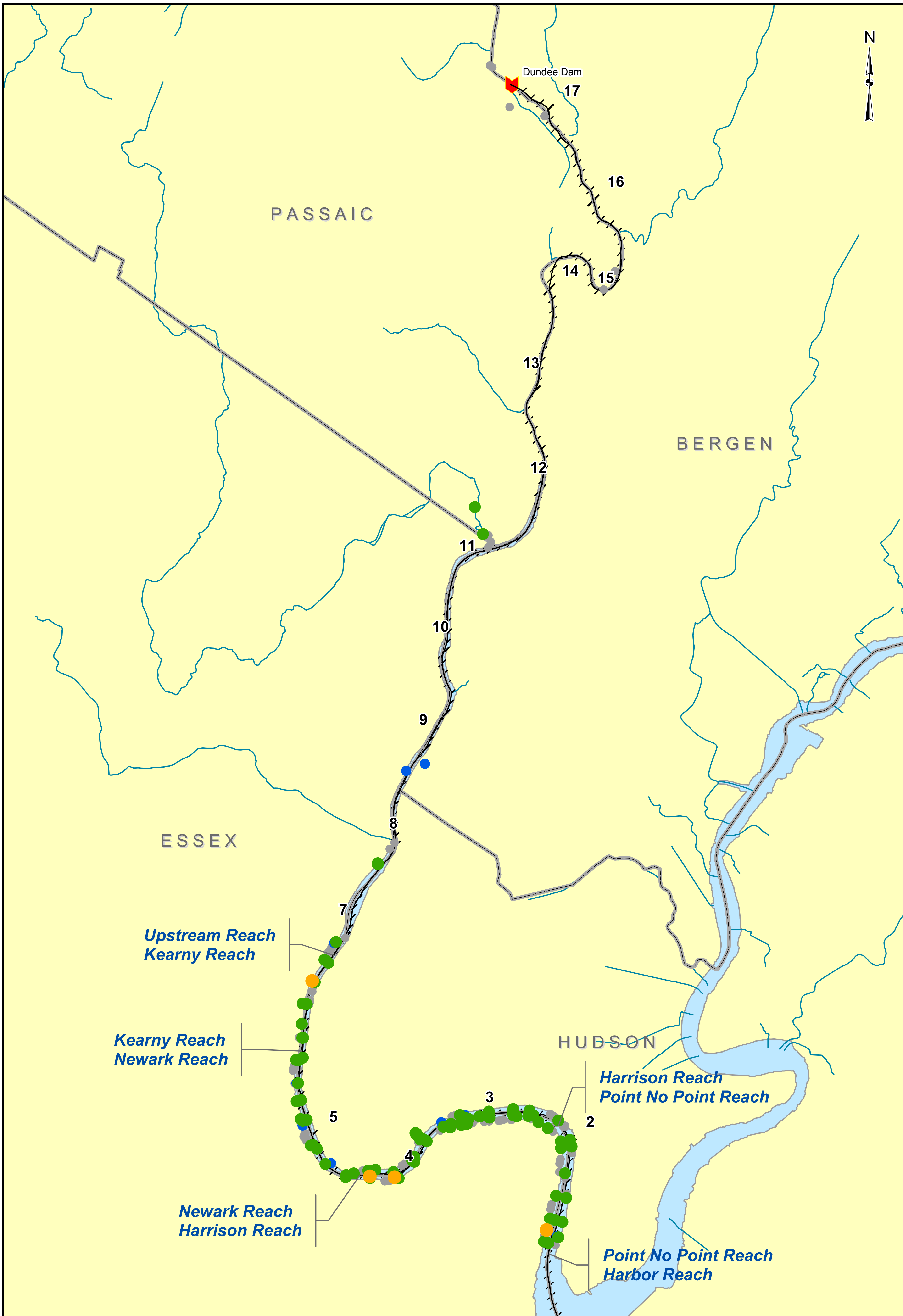


Total Chlordane (ppb)

- 0 - 7
- 8 - 10
- 11 - 100
- 101 - 1,000

0 0.25 0.5 1 Miles

Lower Passaic River Restoration Project
Subsurface Sediment, Harrison Reach
Plate 17

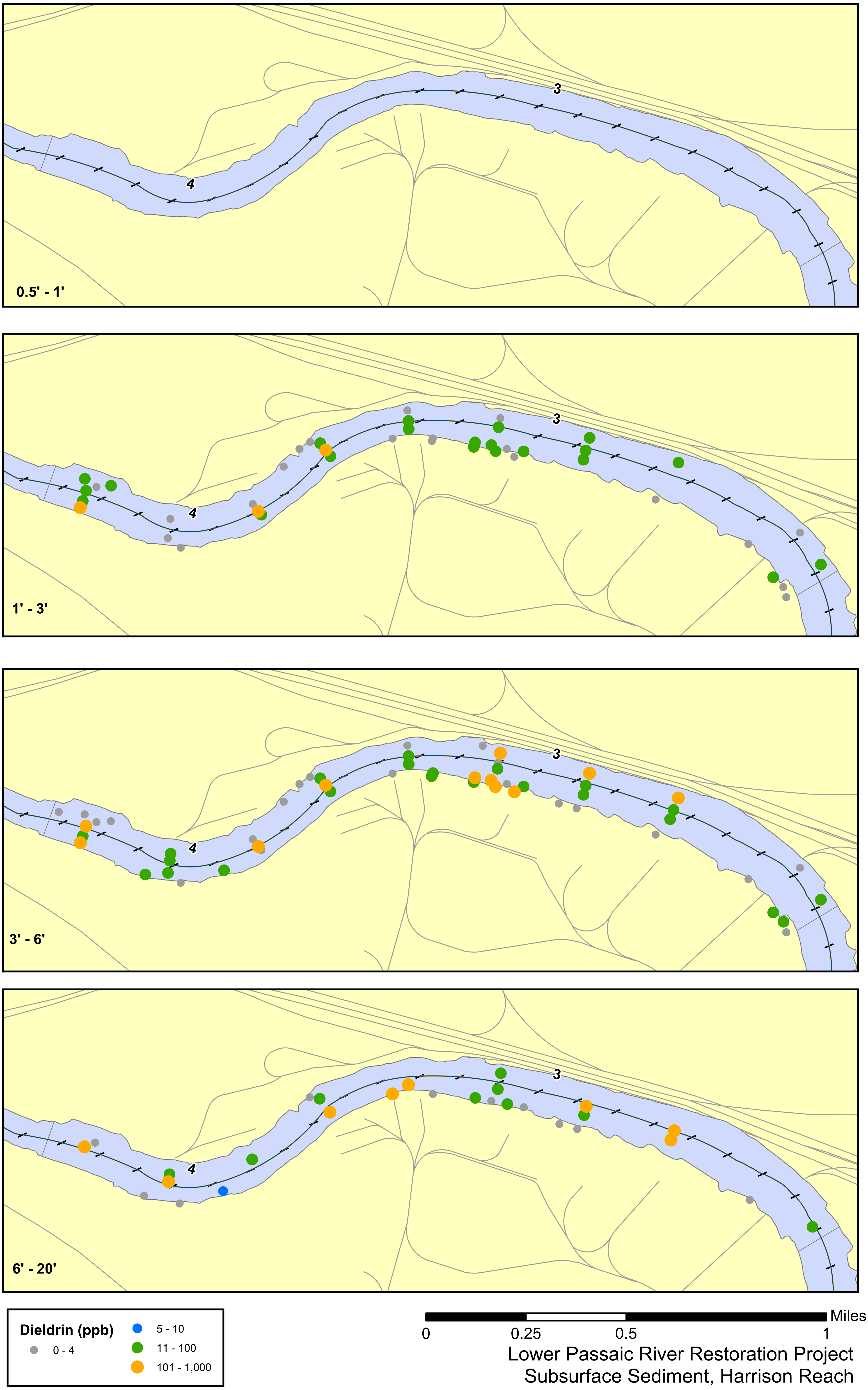


Dieldrin (ppb)

- 0 - 4
- 5 - 10
- 11 - 100
- 101 - 1,000

0 0.5 1 2 Miles

Lower Passaic River Restoration Project
Surficial Sediments
Plate 18



Lower Passaic River Restoration Project
Subsurface Sediment, Harrison Reach
Plate 19

Map Document: (S:\Projects\0285924\MapDocuments\0285924-CERCLA\MXD\HistoricalDataEvaluation\Surface_Metals_Arsenic.mxd)
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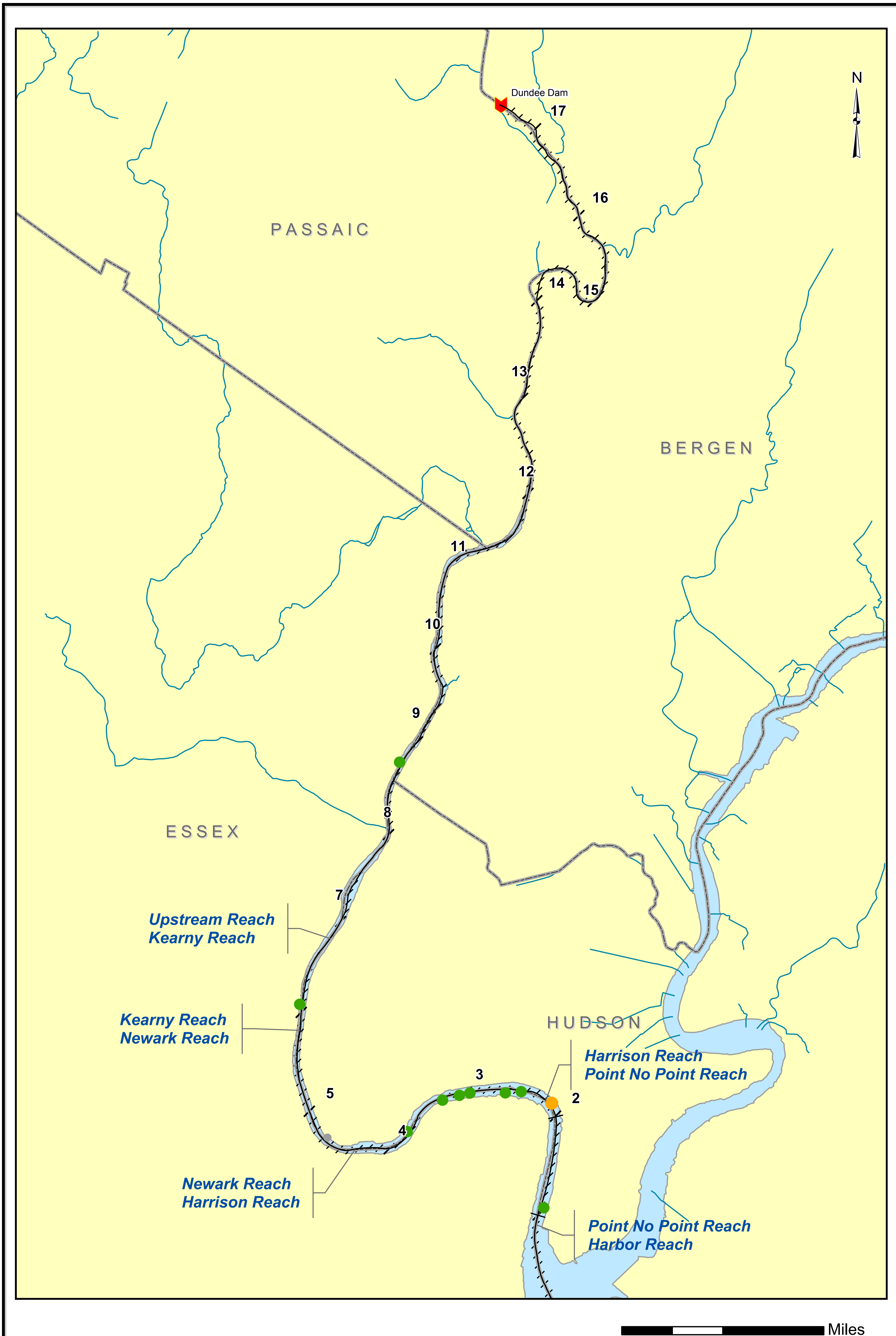
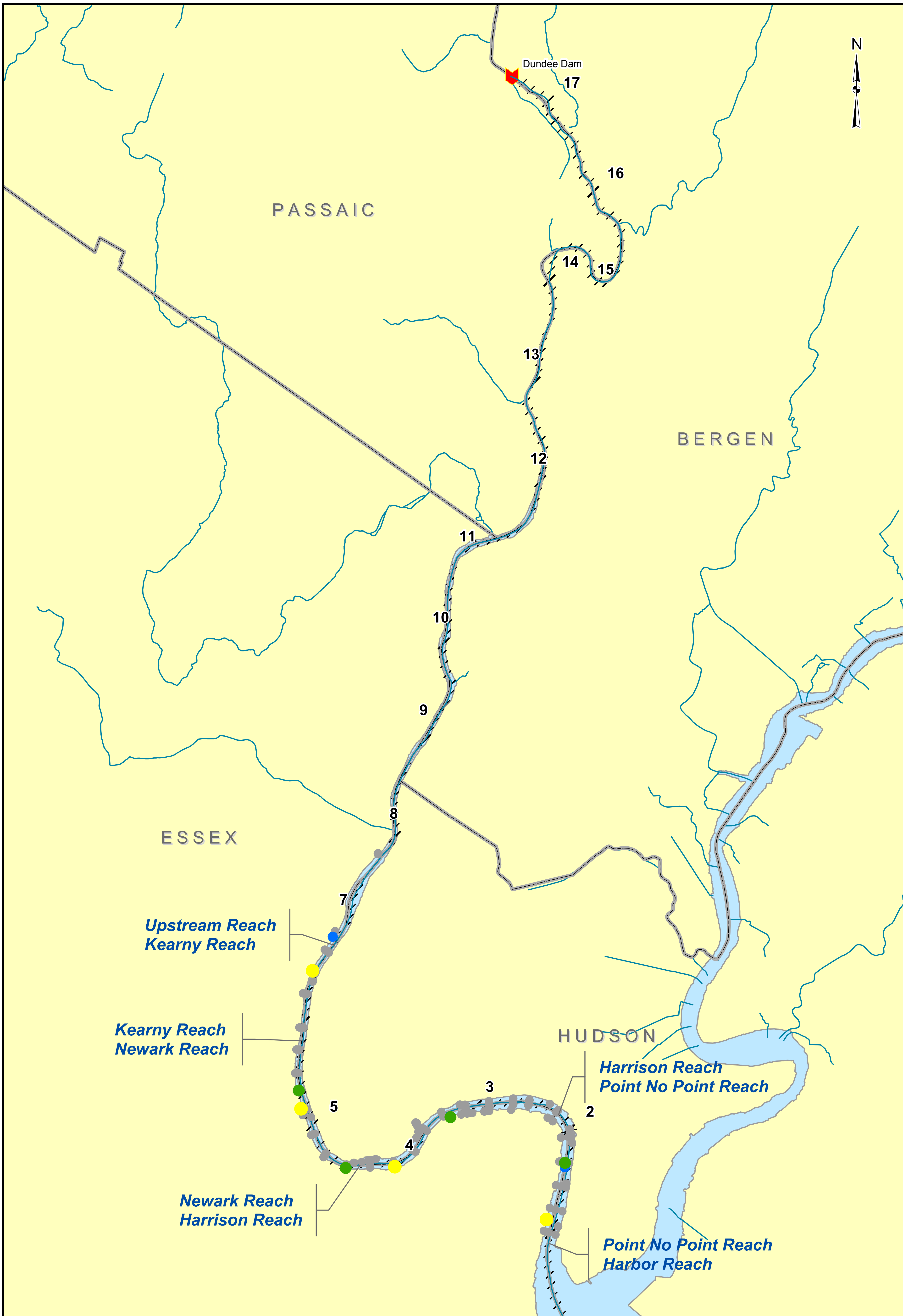


Lower Passaic River Restoration Project
Surficial Sediments
Plate 20



Total Xylenes (ppb)

- 0 - 10
- 11 - 25
- 26 - 100
- 101 - 440

Miles: 0 0.5 1 2

Lower Passaic River Restoration Project
Surficial Sediments
Plate 21

Map Document: (S:\Projects\0285924\MapDocuments\0285924-CERCLA\MXD\HistoricalDataEvaluation\Surface_Metals_Arsenic.mxd)
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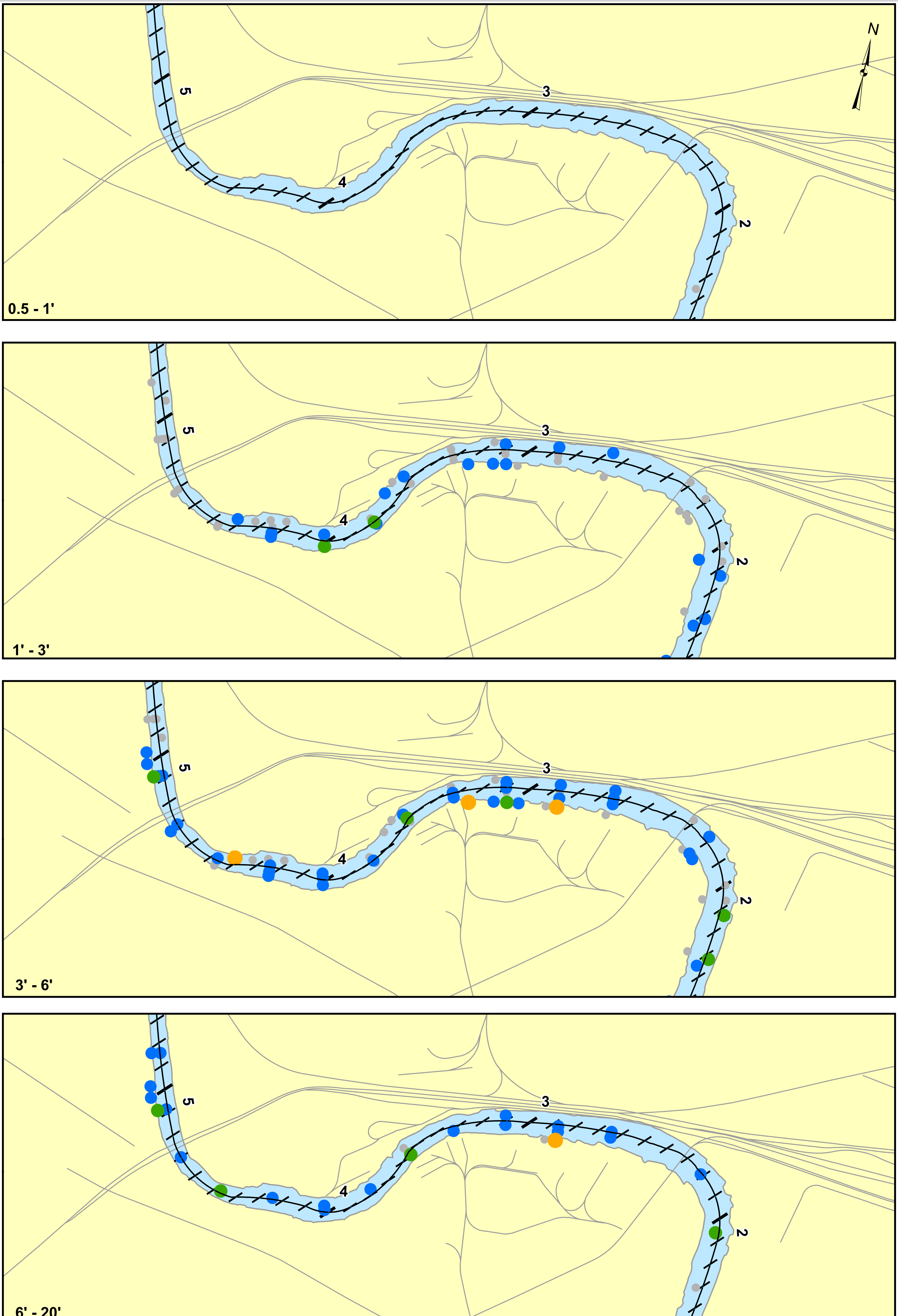
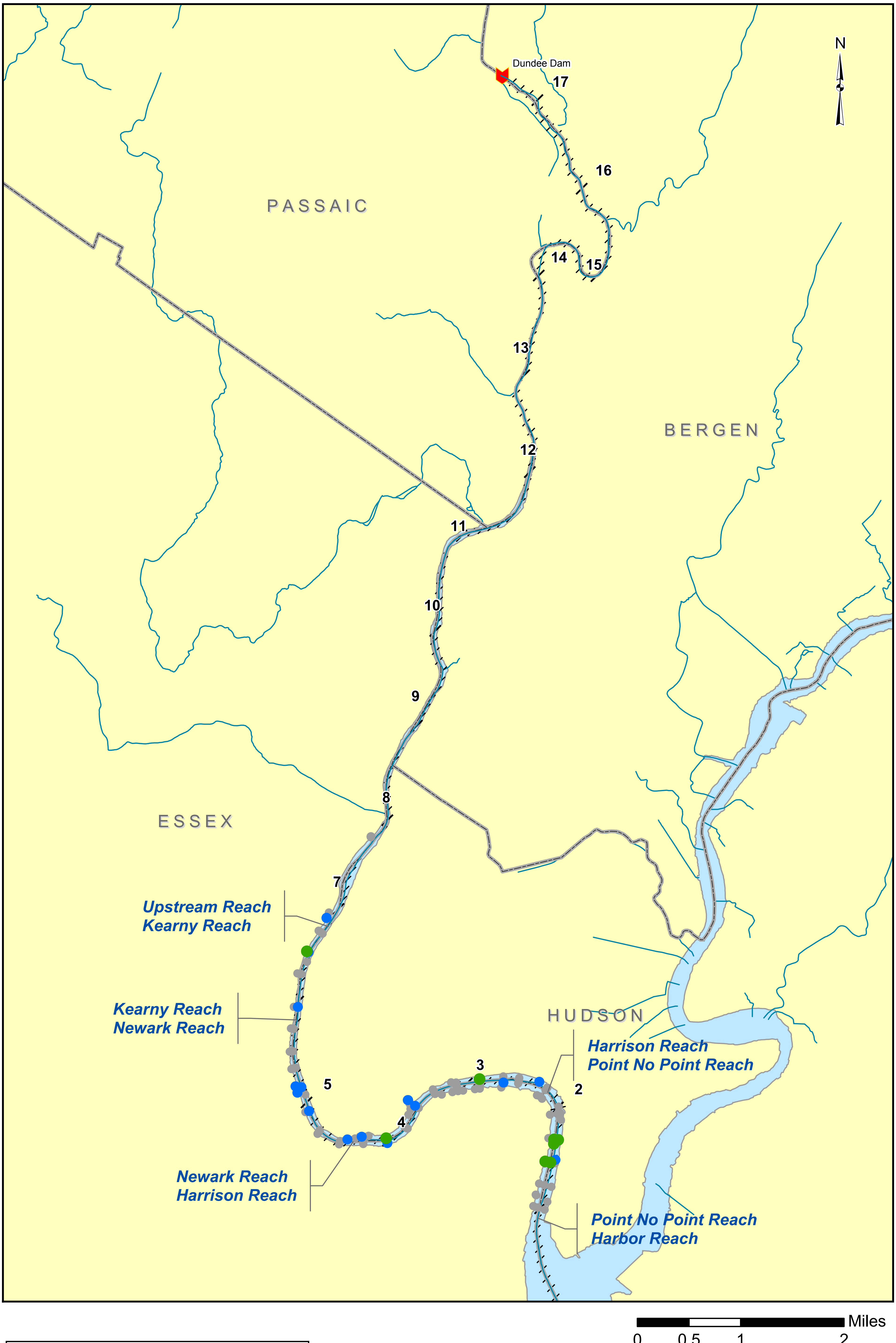


Total Xylenes (ppb)

- 0 - 25
- 26 - 433
- 434 - 4,330
- 4,331 - 44,000

Miles
0 0.25 0.5 1

Lower Passaic River Restoration Project
Subsurface Sediment, River Miles 1.5 - 5.3
Plate 22



Methyl ethyl ketone (ppb)

- 0 - 10
- 11 - 43
- 44 - 100

Lower Passaic River Restoration Project
Surficial Sediments
Plate 23

Map Document: (S:\Projects\0285924\MapDocuments\0285924-CERCLA\MXD\HistoricalDataEvaluation\Surface_Metals_Arsenic.mxd)
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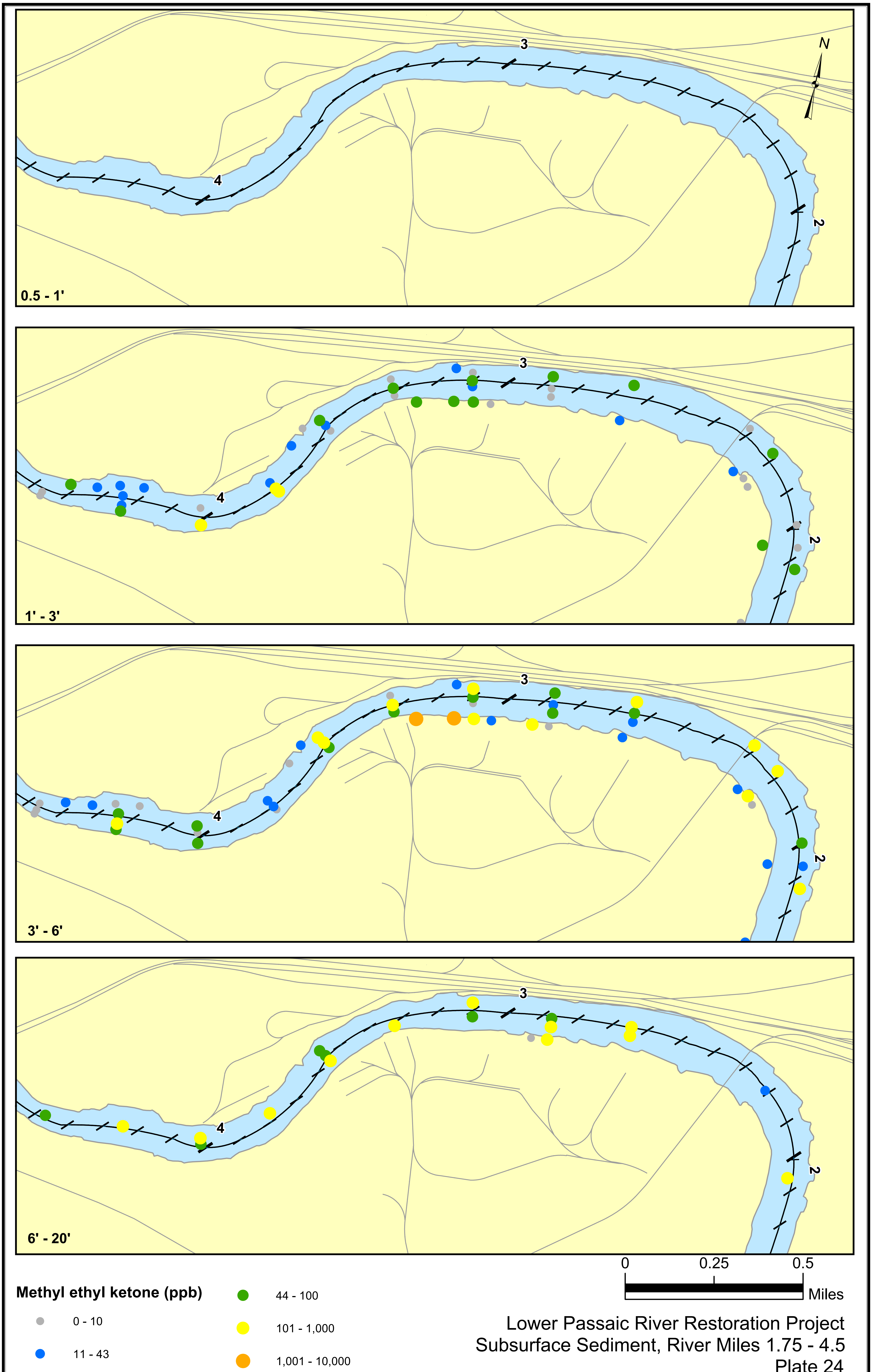
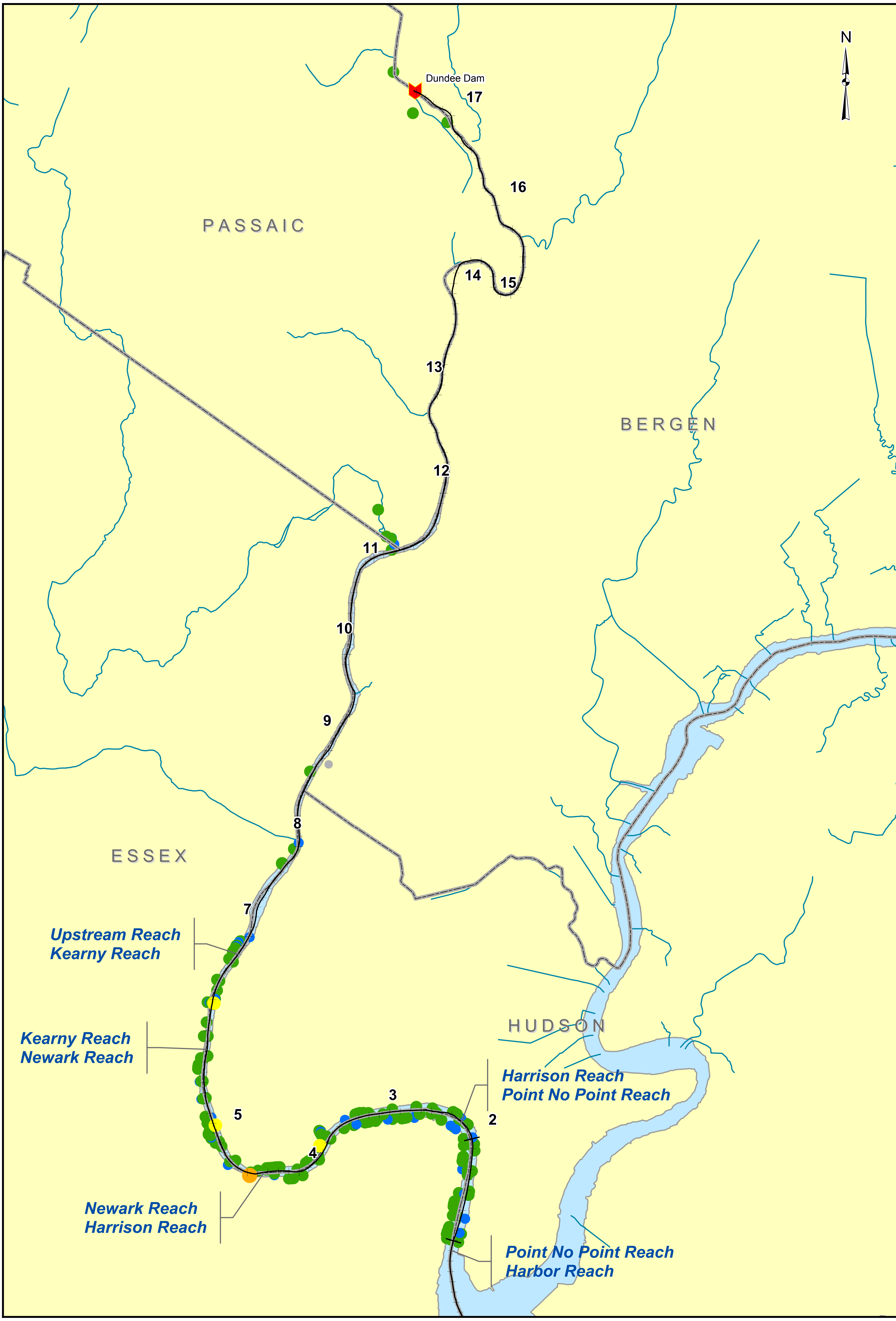


Lower Passaic River Restoration Project
Subsurface Sediment, River Miles 1.75 - 4.5
Plate 24

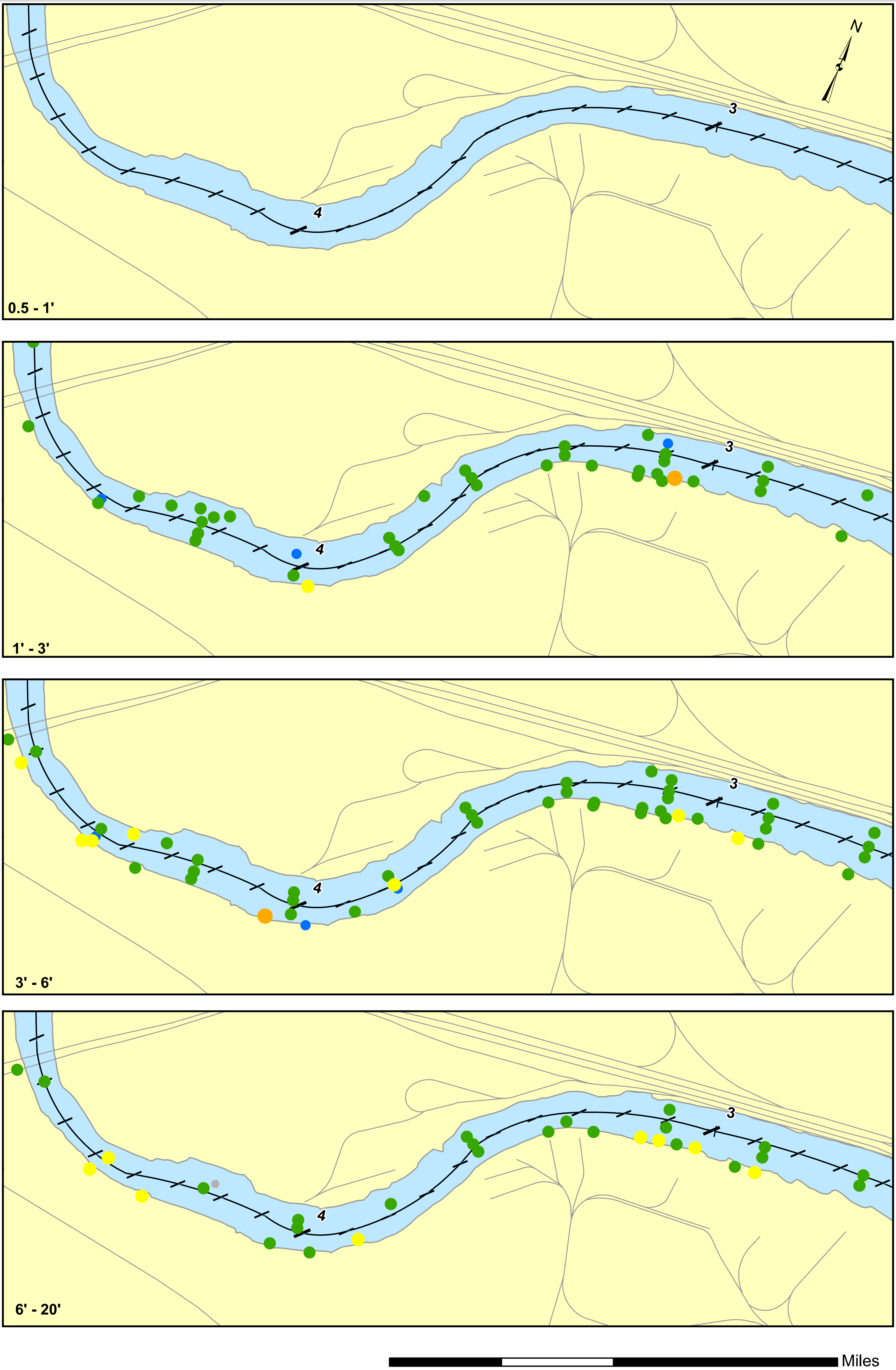


Total High Molecular Weight PAHs (ppb)

- 0 - 1,000
- 1,000 - 10,000
- 10,000 - 100,000
- 100,000 - 1,000,000
- 1,000,000 - 10,000,000

0 0.5 1 2 Miles

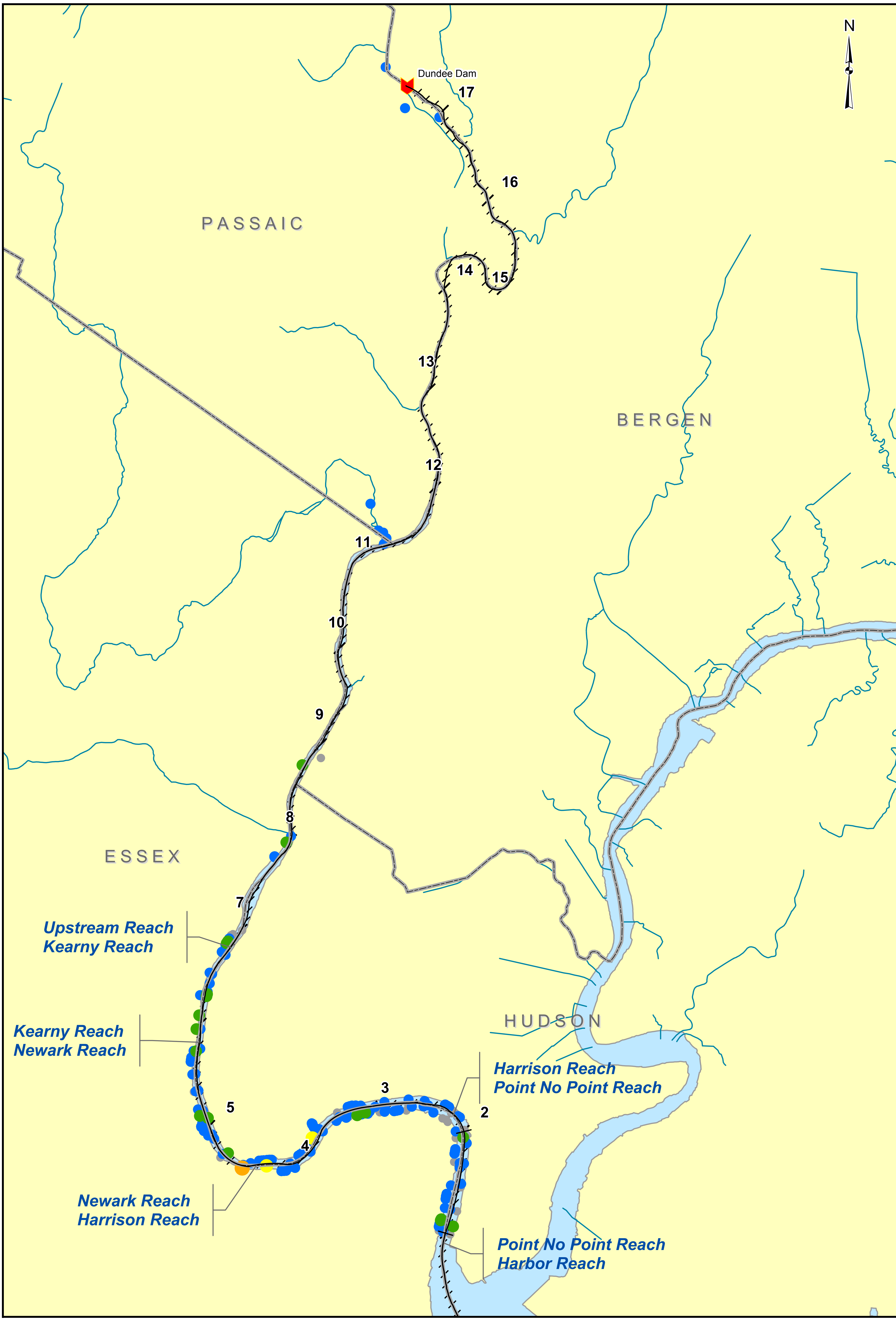
Lower Passaic River Restoration Project
Surficial Sediments
Plate 25



High Molecular Weight PAHs (ppb)

- 220 - 1,000
- 1,001 - 10,000
- 10,001 - 100,000
- 100,001 - 1,000,000
- 1,000,001 - 10,000,000

Lower Passaic River Restoration Project
Subsurface Sediment, River Miles 2.6 - 4.8
Plate 26



Low Molecular Weight PAHs (ppb)

- 0-1,000
- 1,000-10,000
- 10,000-100,000
- 100,000-1,000,000
- 1,000,000-10,000,000

Miles: 0 0.5 1 2

Lower Passaic River Restoration Project
Surficial Sediments
Plate 27

Map Document: (S:\Projects\0285924\MapDocuments\0285924-CERCLA\MXD\HistoricalDataEvaluation\Surface_Metals_Arsenic.mxd)
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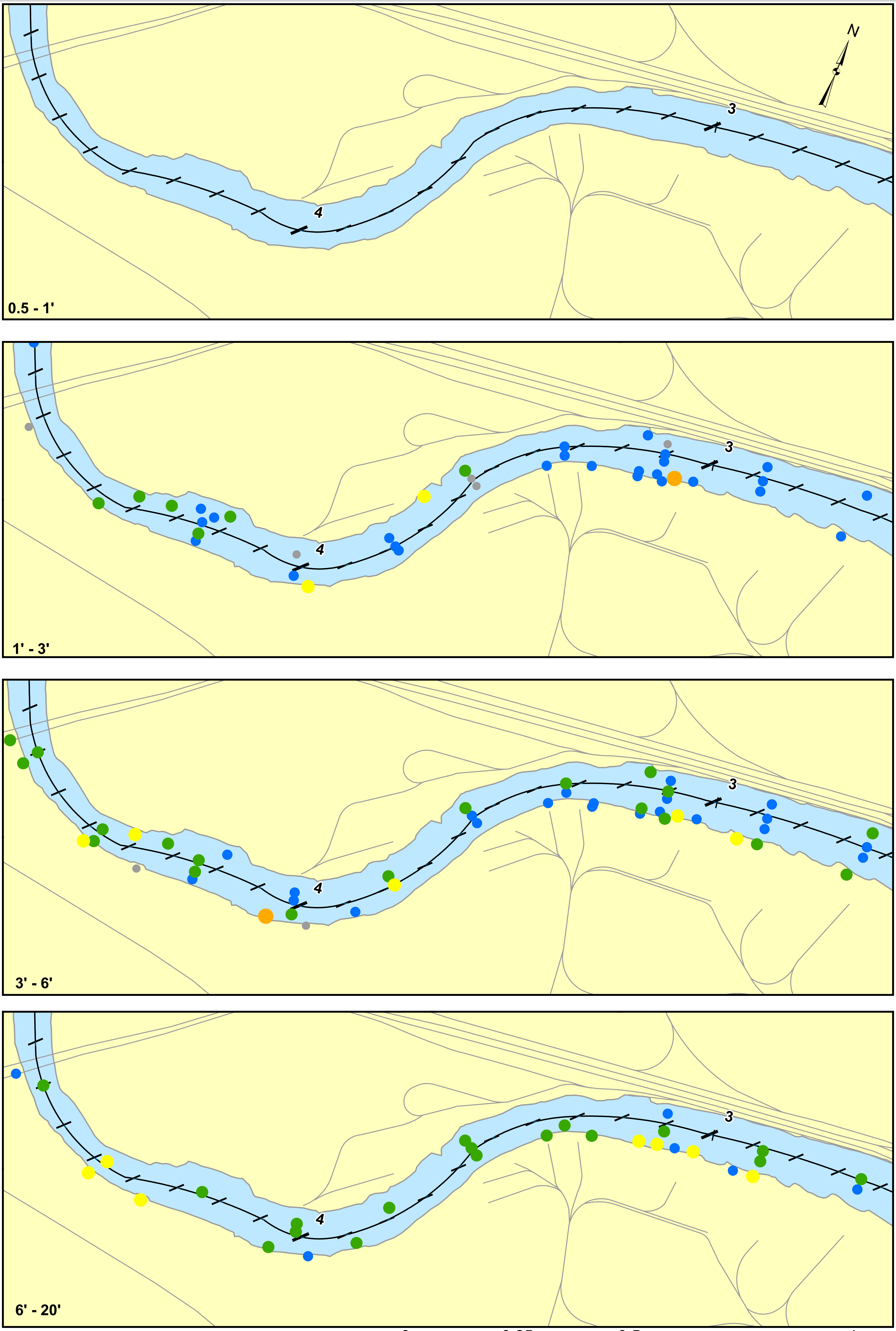
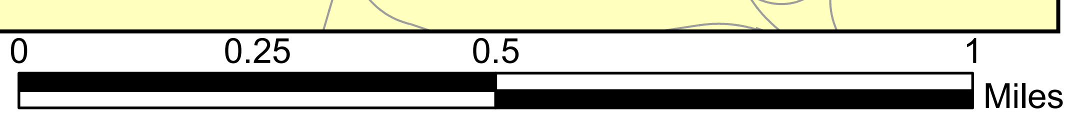
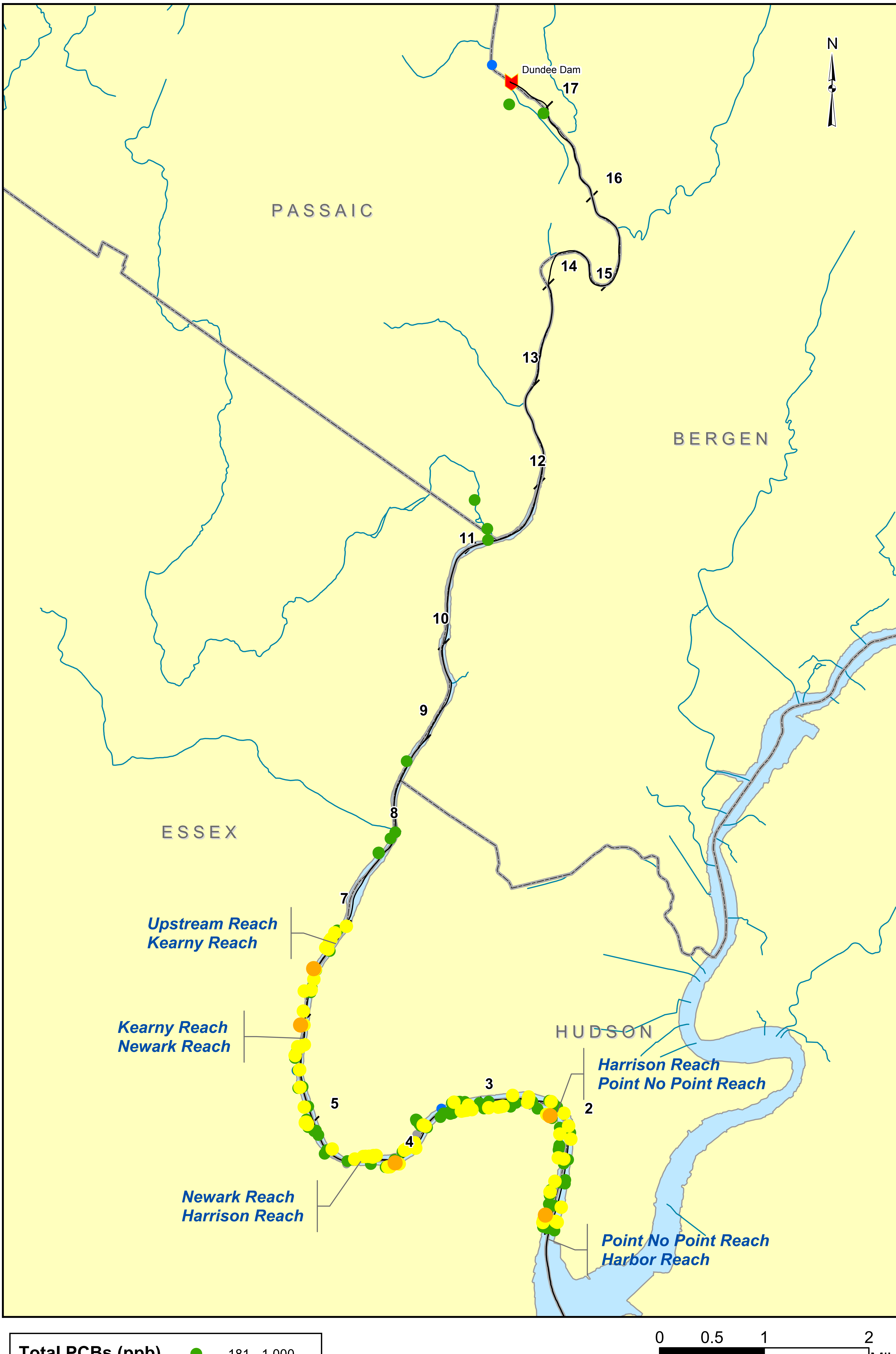




Low Molecular Weight PAHs (ppb)

- 180 - 1,000
- 1,001 - 10,000
- 10,001 - 100,000
- 100,001 - 1,000,000
- 1,000,001 - 10,000,000

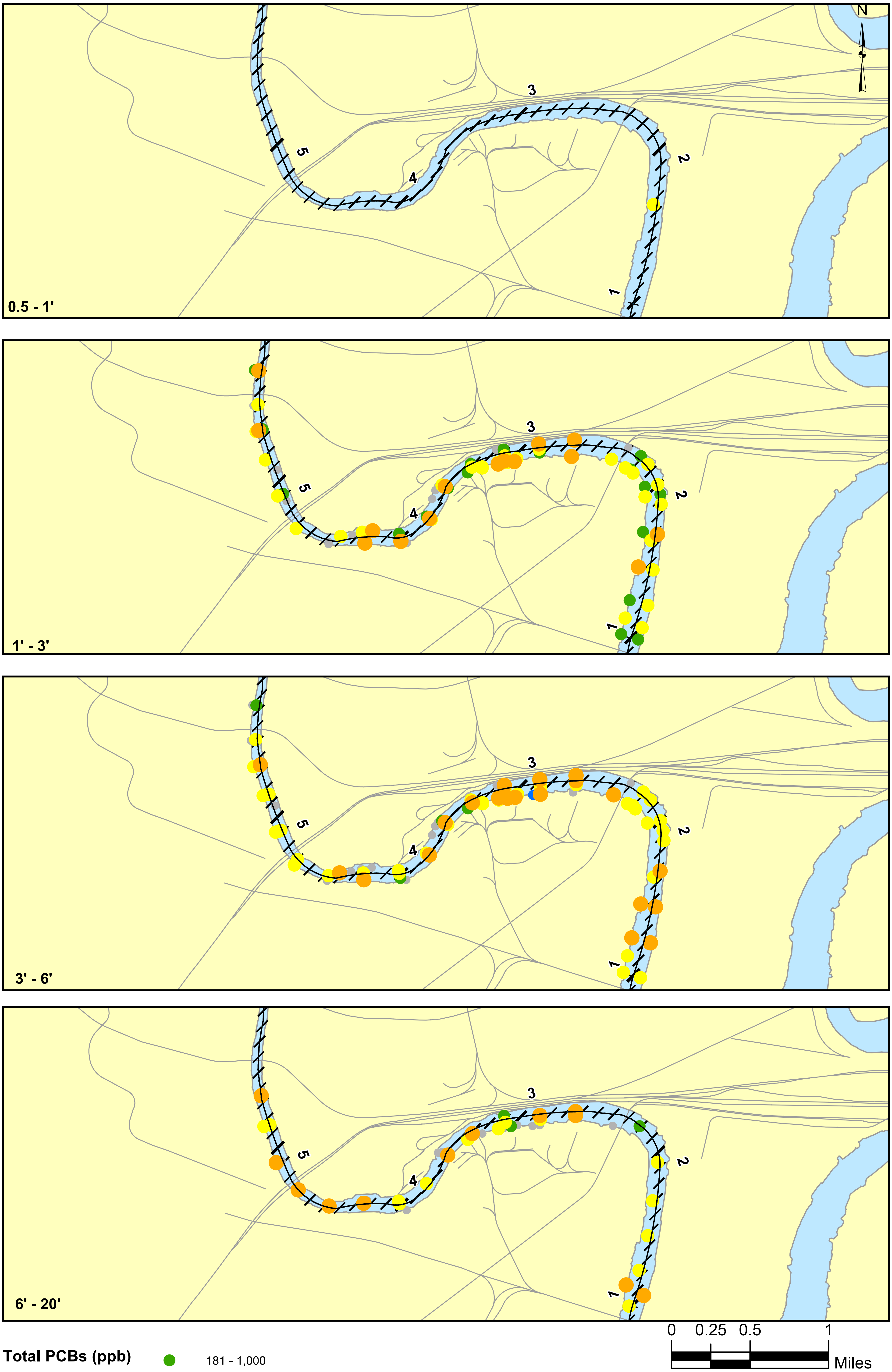
Lower Passaic River Restoration Project
Subsurface Sediment, River Miles 2.6 - 4.8
Plate 28



Total PCBs (ppb)

- 2 - 100
- 101 - 180
- 181 - 1,000
- 1,001 - 5,000
- 5,001 - 17,200

Lower Passaic River Restoration Project
Surficial Sediments
Plate 29

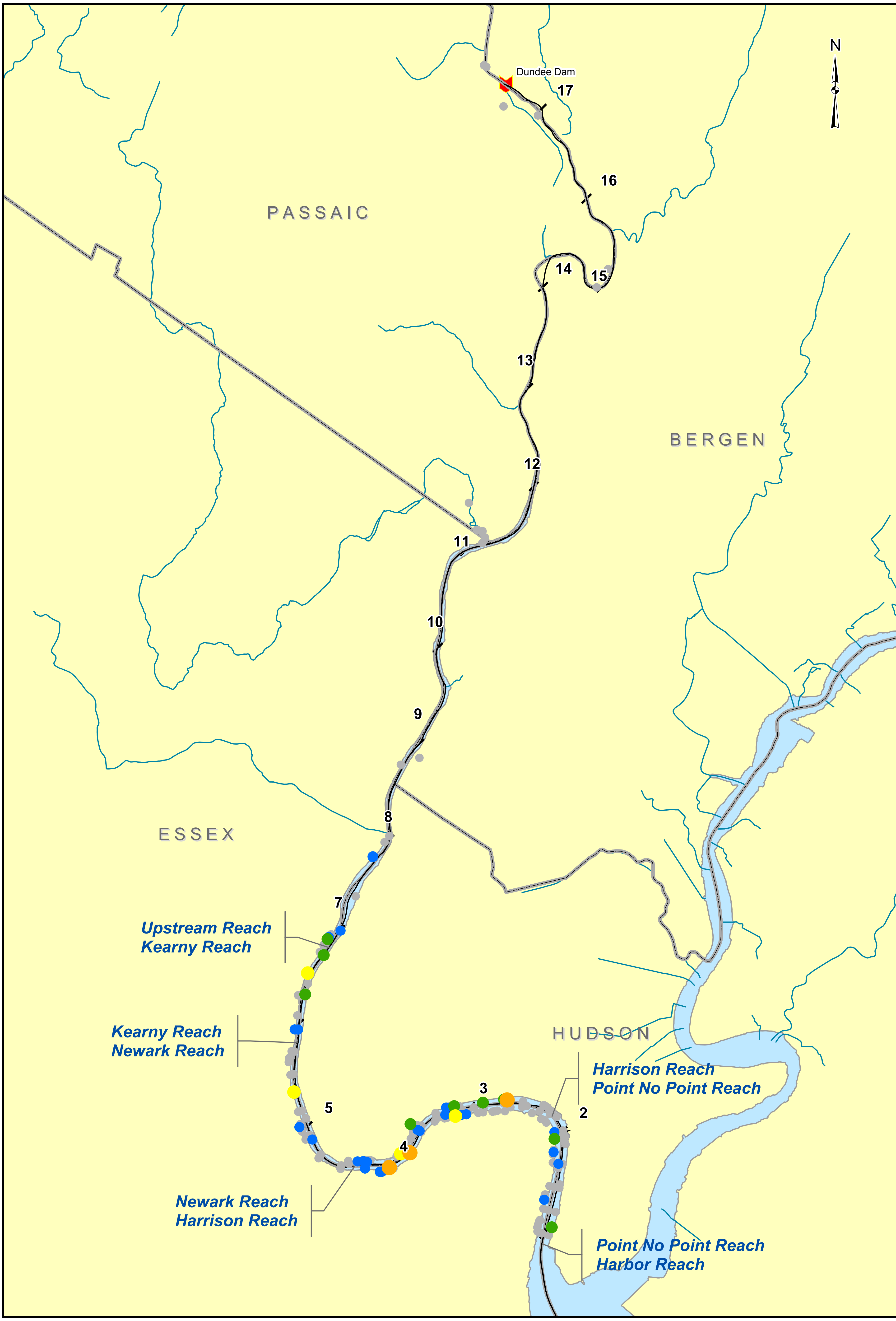


Total PCBs (ppb)

- 0 - 100
- 101 - 180
- 181 - 1,000
- 1,001 - 5,000
- 5,001 - 47,700

Lower Passaic River Restoration Project
Subsurface Sediment, Point No Point, Harrison, and Newark Reaches
Plate 30

Map Document: (S:\Projects\0285924\MapDocuments\0285924-CERCLA\MXD\HistoricalDataEvaluation\Surface_Metals_Arsenic.mxd)
04/15/2004 -- 10:42:11 AM

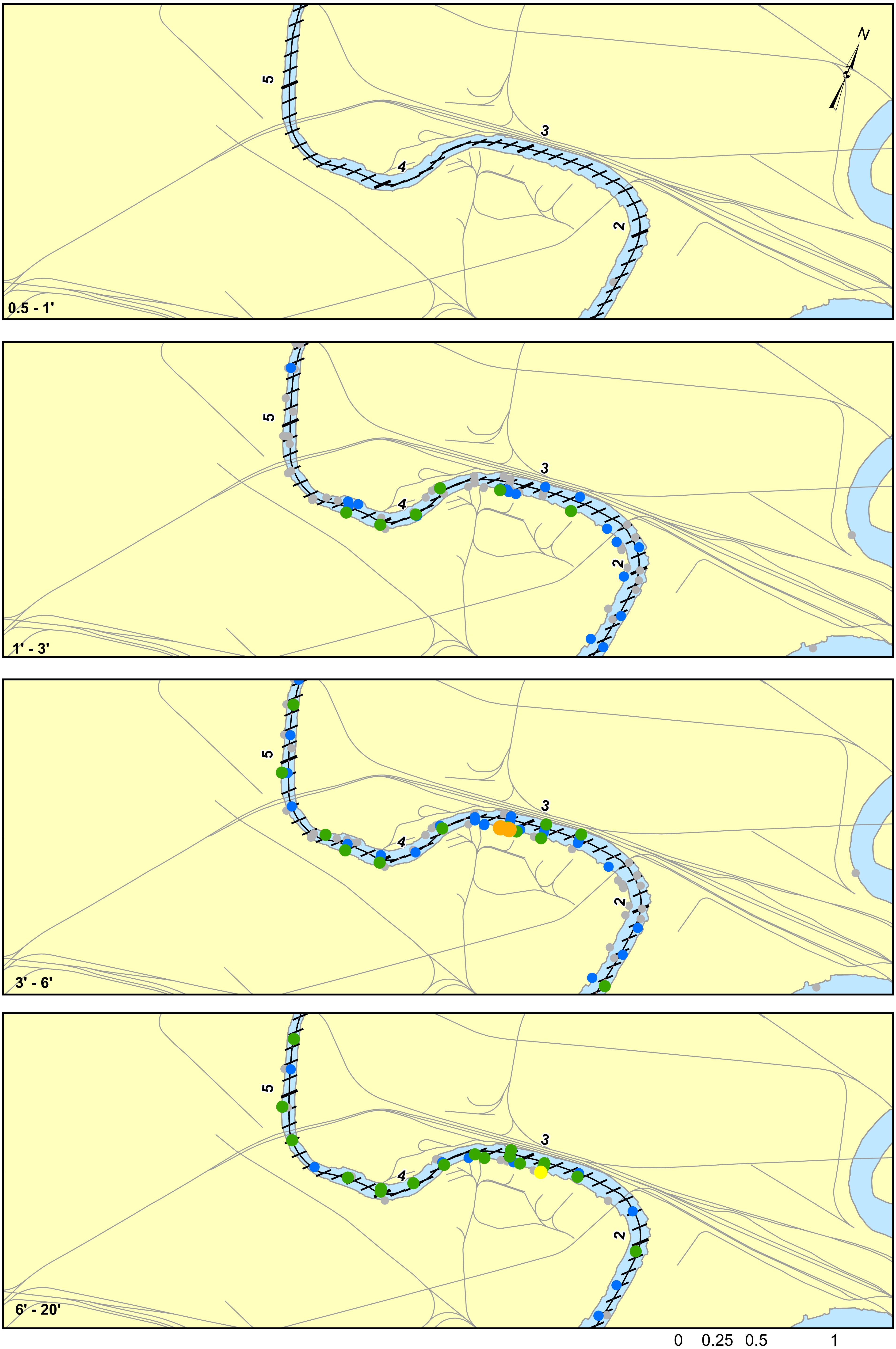


2,3,7,8-TCDD (ppb)

- 0 - 0.5
- 0.5 - 1
- 1 - 3
- 3 - 7
- 7 - 14

0 0.5 1 2 Miles

Lower Passaic River Restoration Project
Surficial Sediments
Plate 31



2,3,7,8-TCDD (ppb)

- 0 - 1
- 2 - 10
- 11 - 100
- 101 - 1,000
- 1,001 - 5,300

Lower Passaic River Restoration Project
Subsurface Sediment, Point No Point, Harrison, and Newark Reaches Plate 32

Map Document: (S:\Projects\0285924\MapDocuments\0285924-CERCLA\MXD\HistoricalDataEvaluation\Surface_Metals_Arsenic.mxd)
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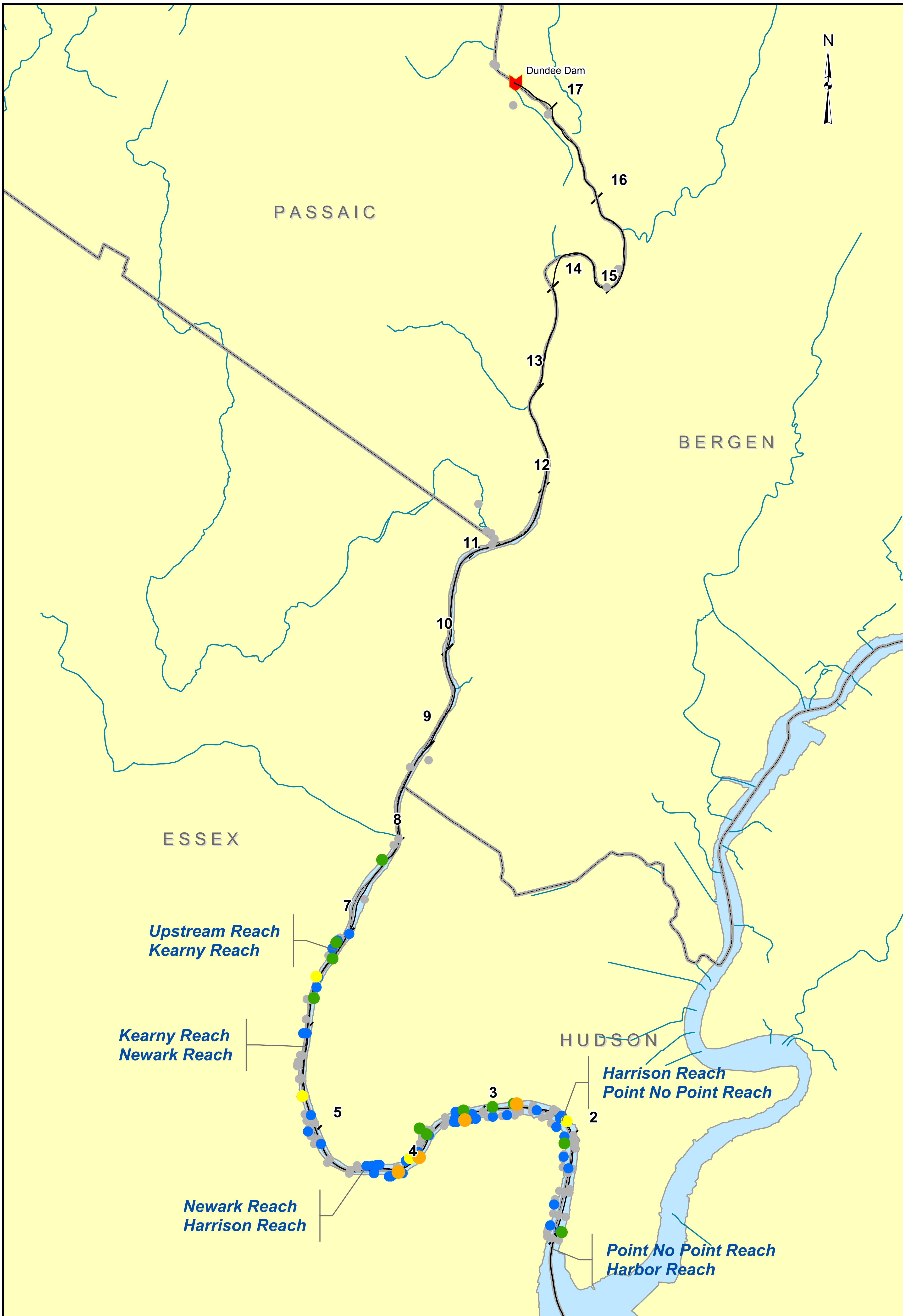
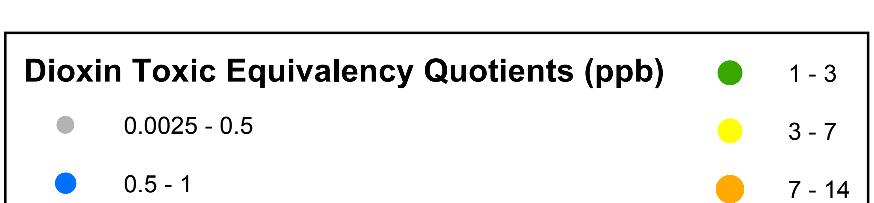
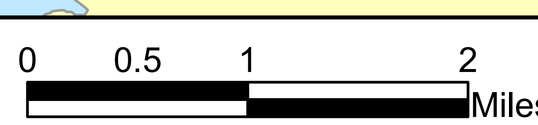
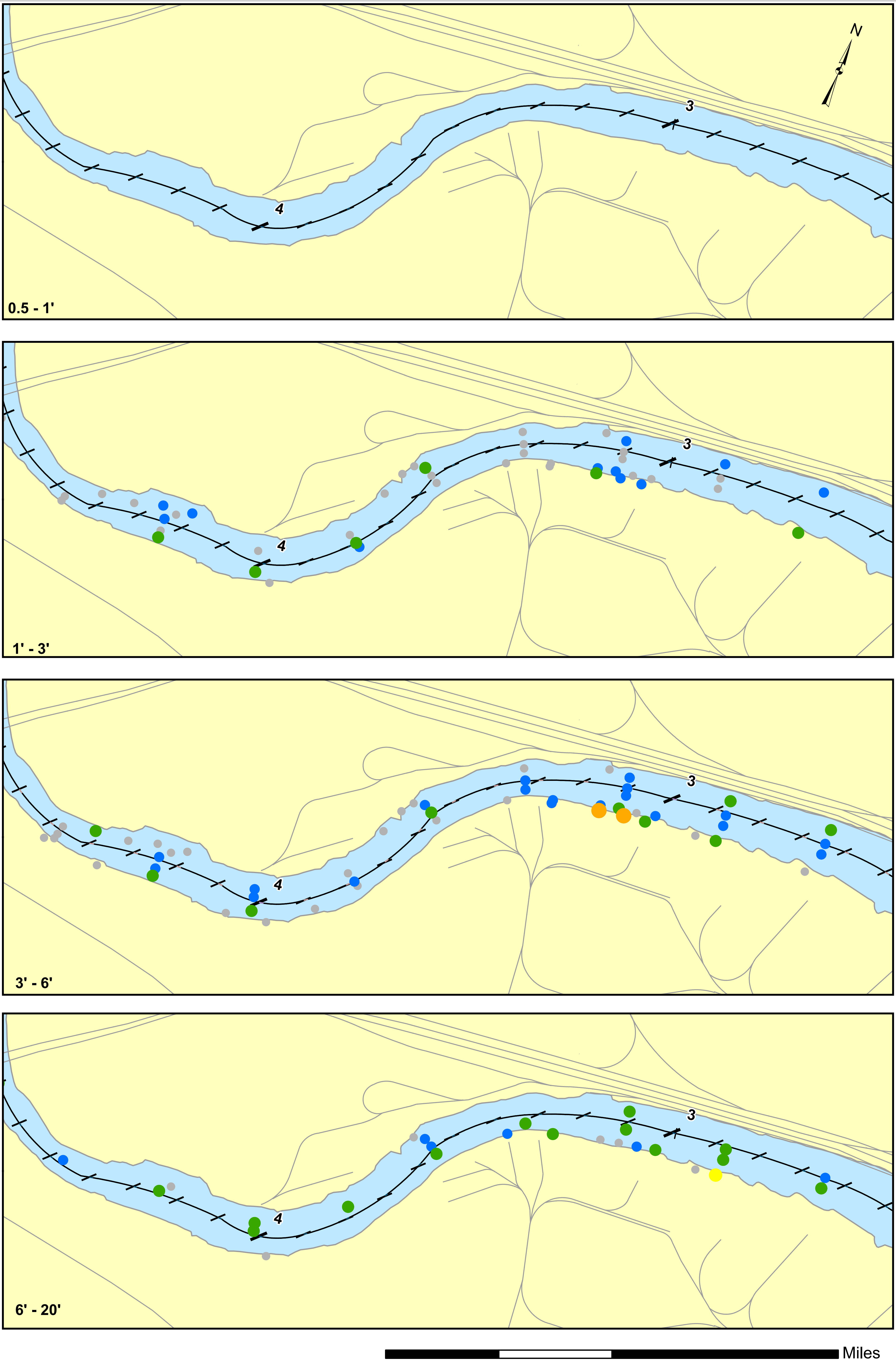






Lower Passaic River Restoration Project
Surficial Sediments
Plate 33

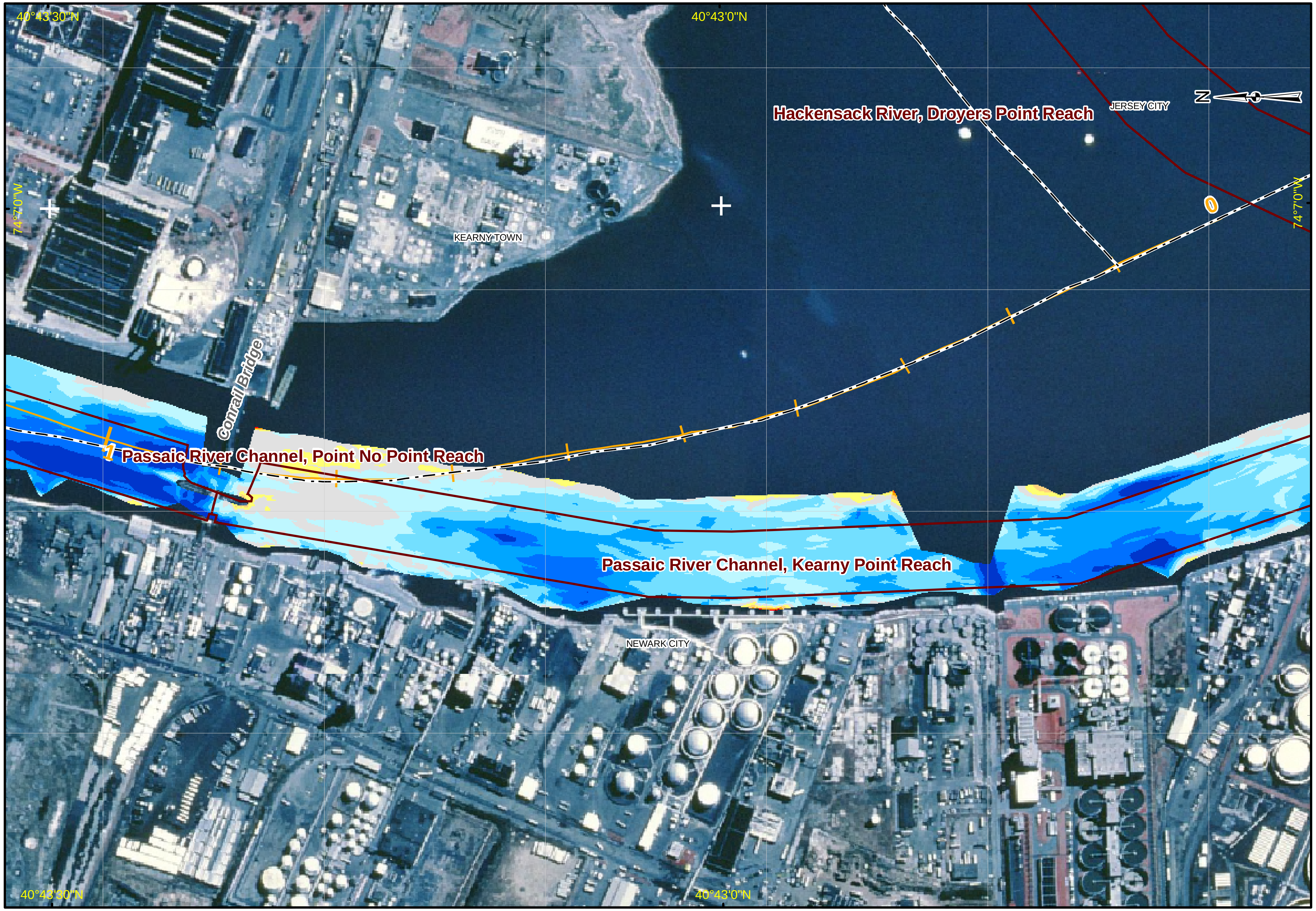


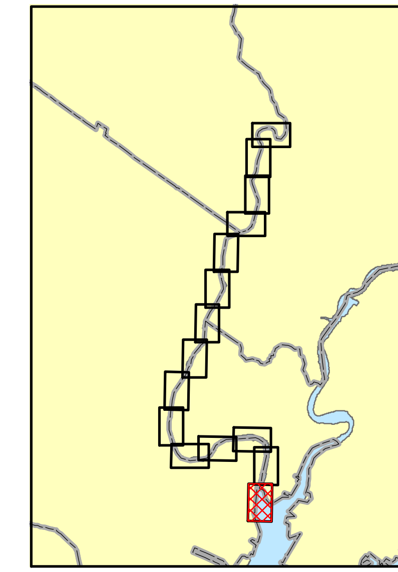
Dioxin Toxic Equivalency Quotients (ppb)

- 0 - 1
- 2 - 10
- 11 - 100
- 101 - 1,000
- 1,001 - 10,000

Lower Passaic River Restoration Project
Subsurface Sediment, Harrison Reach
Plate 34

Plate 35: Left Intentionally Blank





Legend

- River Centerline
- River Mile Post
- Municipalities
- Navigation Channel

Change in Depth (feet)

- < -9 (Heavy Scour)
- -9 - -7
- -7 - -5
- -5 - -3
- -3 - -1
- -1 - 1 (Neutral)
- 1 - 3
- 3 - 5
- 5 - 7
- 7 - 9
- > 9 (Heavy Deposition

Data Sources:
1. 1995 - 1997 Digital Orthophotos (NJDEP)
2. USACE/TGVEA 1989 Bathymetric Survey Points
3. USACE 2004 Bathymetric Survey Points

Coordinate System: State Plane New Jersey
Horizontal Datum: NAD 83
Vertical Datum: NGVD 29
Units: Feet

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The change in depth was calculated by subtracting the 1989 raster surface from the 2004 raster surface.

0 250 500 1,000

1 " equals 500 '

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Lower Passaic River, New Jersey

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1989 - 2004 Change in River Depth

Plate 36: Mile 0 to 1

Map Document: (S:\Projects\PASSAIC\MapDocuments\MXD\1989-2004 Bathymetry\Bathymetry_comparison_mapbook.mxd)
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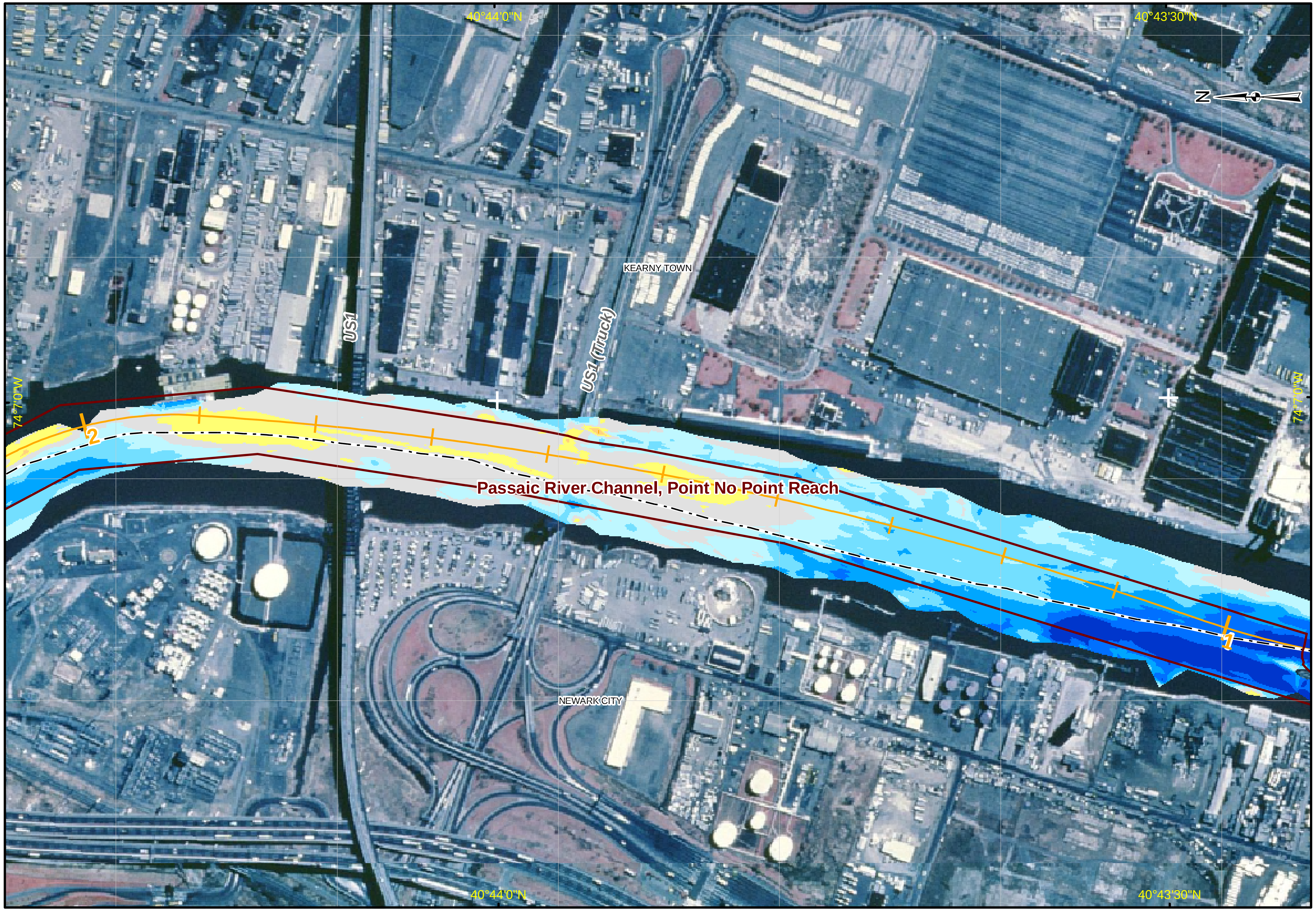

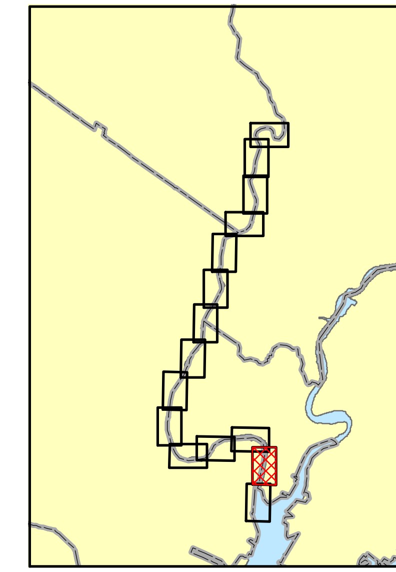

Legend

- River Centerline
- River Mile Post
- Municipalities
- Navigation Channel

Change in Depth (feet)

- < -9 (Heavy Scour)
- -9 - -7
- -7 - -5
- -5 - -3
- -3 - -1
- -1 - 1 (Neutral)
- 1 - 3
- 3 - 5
- 5 - 7
- 7 - 9
- > 9 (Heavy Deposition

Data Sources:
1. 1995 - 1997 Digital Orthophotos (NJDEP)
2. USACE/TGVEA 1989 Bathymetric Survey Points
3. USACE 2004 Bathymetric Survey Points

Coordinate System: State Plane New Jersey
Horizontal Datum: NAD 83
Vertical Datum: NGVD 29
Units: Feet

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The change in depth was calculated by subtracting the 1989 raster surface from the 2004 raster surface.

0 250 500 1,000

1 " equals 500 '

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1989 - 2004 Change in River Depth

Plate 37: Mile 1 to 2

Map Document: (S:\Projects\PASSAIC\MapDocuments\MXD\1989-2004 Bathymetry\Bathymetry_comparison_mapbook.mxd)
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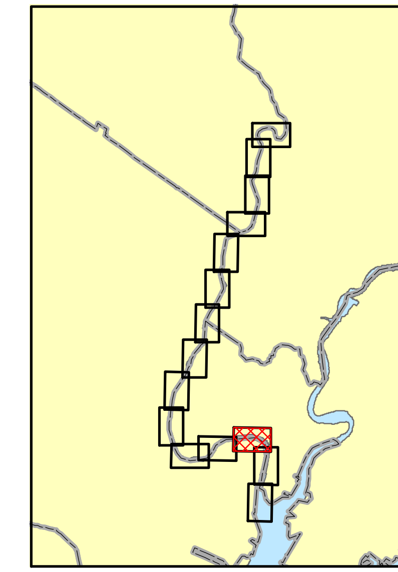

Legend

- River Centerline
- River Mile Post
- Municipalities
- Navigation Channel

Change in Depth (feet)

- < -9 (Heavy Scour)
- -9 - -7
- -7 - -5
- -5 - -3
- -3 - -1
- -1 - 1 (Neutral)
- 1 - 3
- 3 - 5
- 5 - 7
- 7 - 9
- > 9 (Heavy Deposition)

Data Sources:
1. 1995 - 1997 Digital Orthophotos (NJDEP)
2. USACE/TGVEA 1989 Bathymetric Survey Points
3. USACE 2004 Bathymetric Survey Points

Coordinate System: State Plane New Jersey
Horizontal Datum: NAD 83
Vertical Datum: NGVD 29
Units: Feet

Sounding depths from the 1989 Survey were converted from USACE Mean Low Water (MLW) to NGVD29 using a factor of 2.4 feet downstream of River Mile 6.8 and 2.3 feet upstream of River Mile 6.8.

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The change in depth was calculated by subtracting the 1989 raster surface from the 2004 raster surface.

0 250 500 1,000

1 " equals 500 '

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Lower Passaic River, New Jersey

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1989 - 2004 Change in River Depth

Plate 38: Mile 2 to 3

Map Document: (S:\Projects\PASSAIC\MapDocuments\MXD\1989-2004 Bathymetry\Bathymetry_comparison_mapbook.mxd)
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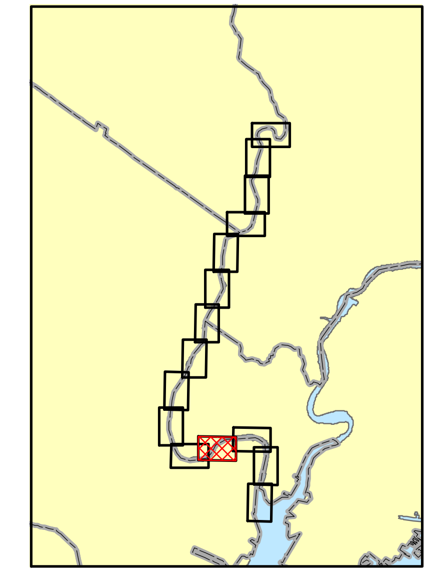

Legend

- River Centerline
- River Mile Post
- Municipalities
- Navigation Channel

Change in Depth (feet)

- < -9 (Heavy Scour)
- -9 - -7
- -7 - -5
- -5 - -3
- -3 - -1
- -1 - 1 (Neutral)
- 1 - 3
- 3 - 5
- 5 - 7
- 7 - 9
- > 9 (Heavy Deposition

Data Sources:
1. 1995 - 1997 Digital Orthophotos (NJDEP)
2. USACE/TGVEA 1989 Bathymetric Survey Points
3. USACE 2004 Bathymetric Survey Points

Coordinate System: State Plane New Jersey
Horizontal Datum: NAD 83
Vertical Datum: NGVD 29
Units: Feet

Sounding depths from the 1989 Survey were converted from USACE Mean Low Water (MLW) to NGVD29 using a factor of 2.4 feet downstream of River Mile 6.8 and 2.3 feet upstream of River Mile 6.8.

A Triangulated Irregular Network (TIN) was derived from the survey points for each dataset using ESRI's 3-D Analyst in ArcGIS. Contours were interpolated from the TIN, also in 3-D Analyst. Each surface was converted to a raster with a 5-foot grid cell size.

The change in depth was calculated by subtracting the 1989 raster surface from the 2004 raster surface.

0 250 500 1,000

1 " equals 500 '

Plate 39: Mile 3 to 4

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Lower Passaic River, New Jersey

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1989 - 2004 Change in River Depth

Map Document: (S:\Projects\PASSAIC\MapDocuments\MXD\1989-2004 Bathymetry\Bathymetry_comparison_mapbook.mxd)
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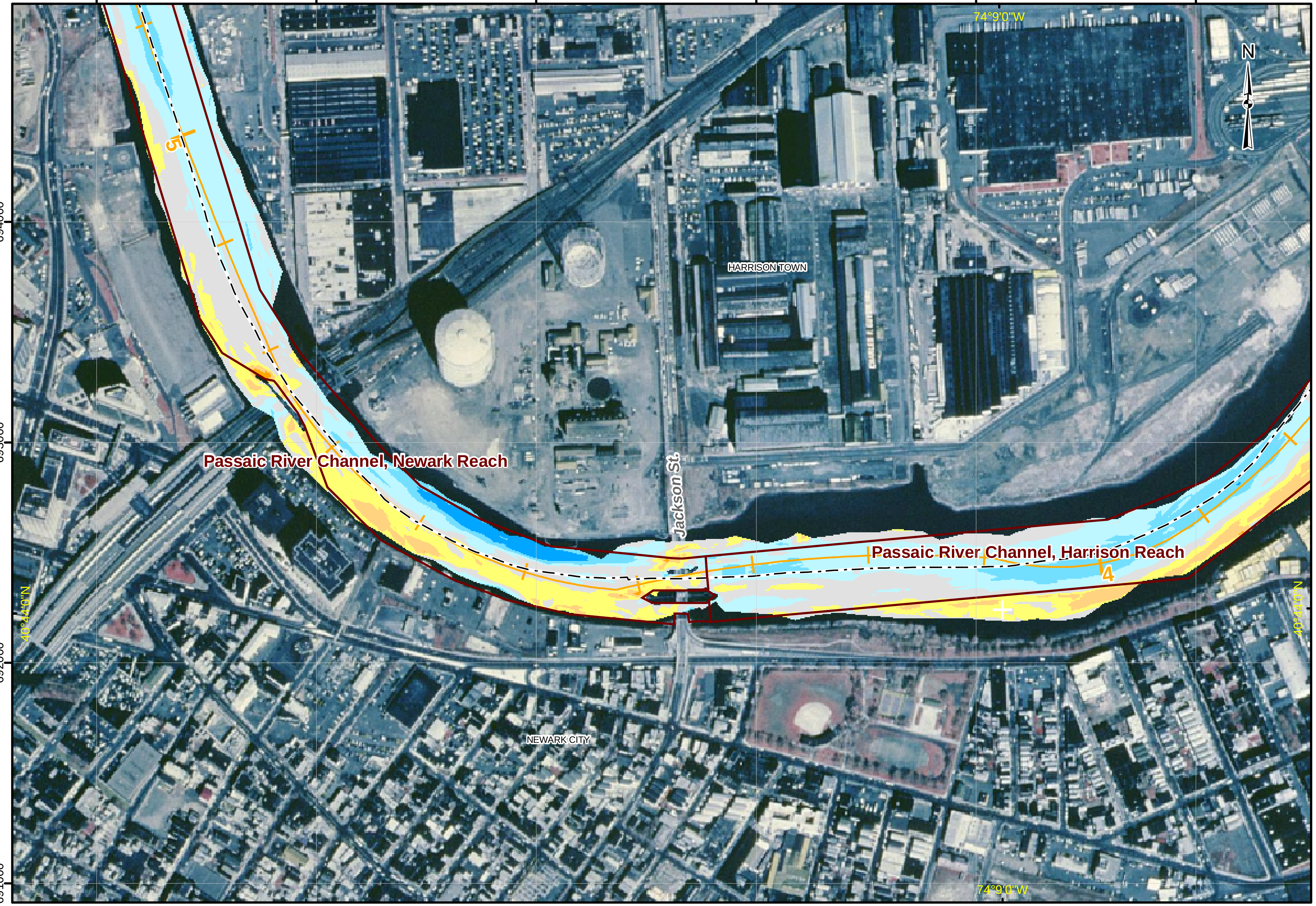

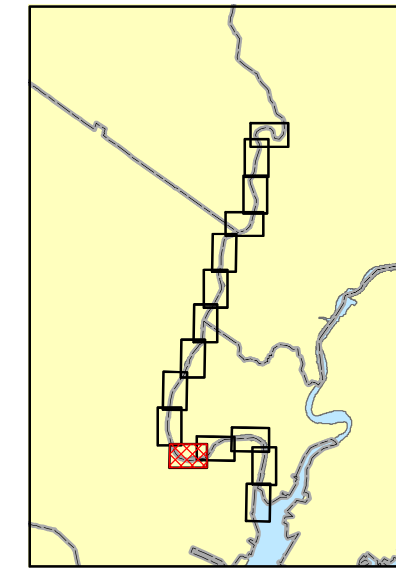

Legend

- River Centerline
- River Mile Post
- Municipalities
- Navigation Channel

Change in Depth (feet)

- < -9 (Heavy Scour)
- -9 - -7
- -7 - -5
- -5 - -3
- -3 - -1
- -1 - 1 (Neutral)
- 1 - 3
- 3 - 5
- 5 - 7
- 7 - 9
- > 9 (Heavy Deposition

Data Sources:
1. 1995 - 1997 Digital Orthophotos (NJDEP)
2. USACE/TGVEA 1989 Bathymetric Survey Points
3. USACE 2004 Bathymetric Survey Points

Coordinate System: State Plane New Jersey
Horizontal Datum: NAD 83
Vertical Datum: NGVD 29
Units: Feet

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The change in depth was calculated by subtracting the 1989 raster surface from the 2004 raster surface.

0 250 500 1,000

1 " equals 500 '

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1989 - 2004 Change in River Depth

Plate 40: Mile 4 to 5

Map Document: (S:\Projects\PASSAIC\MapDocuments\MXD\1989-2004 Bathymetry\Bathymetry_comparison_mapbook.mxd)
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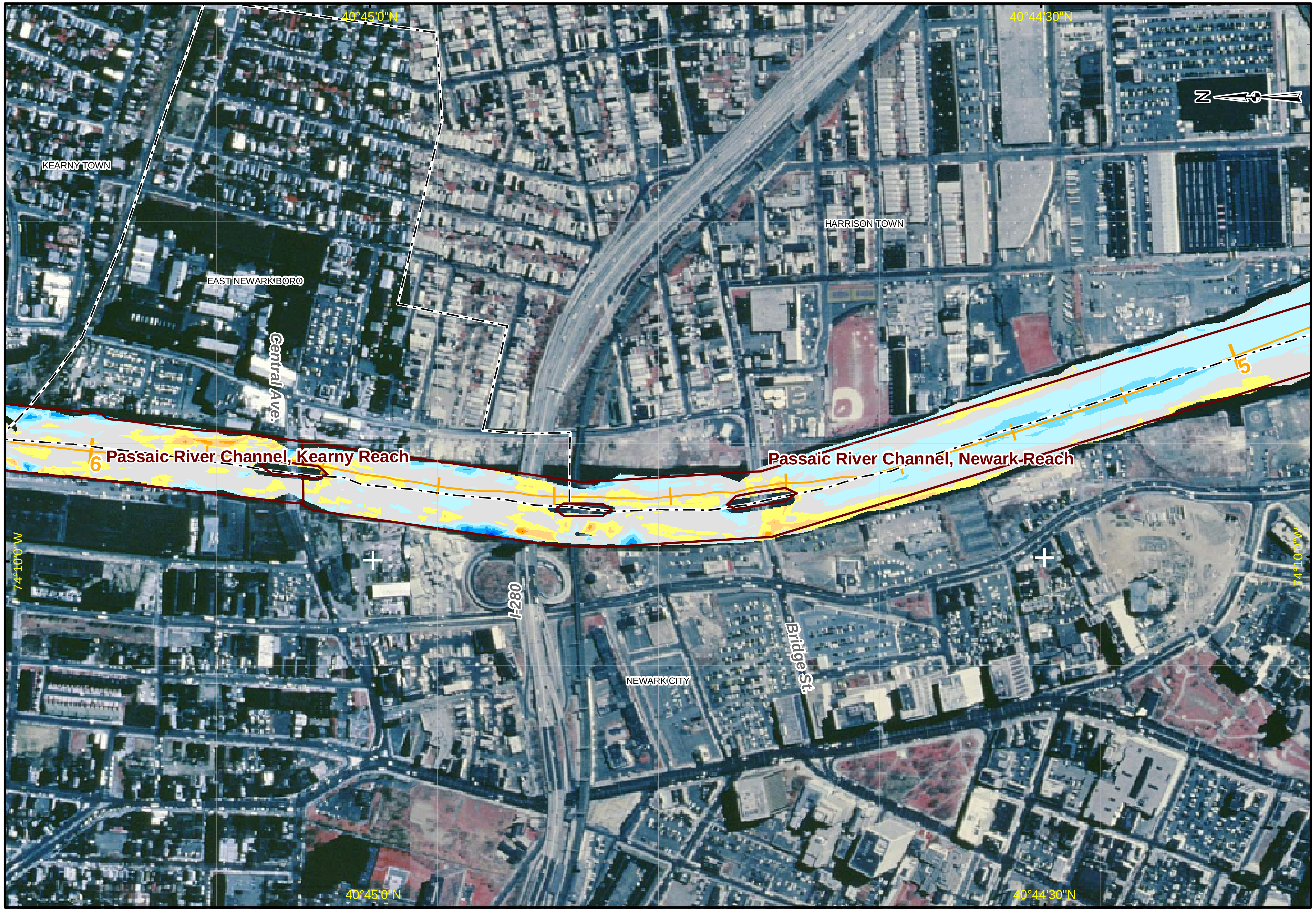

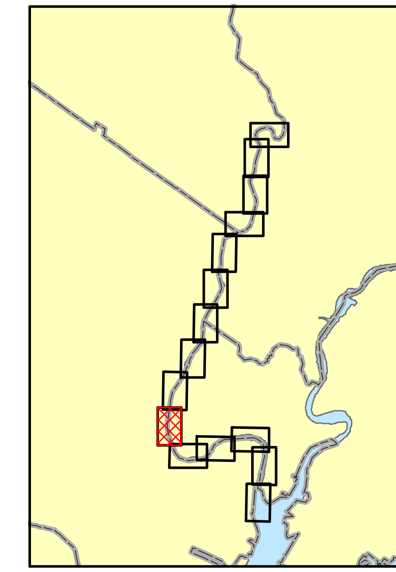

Legend

- River Centerline
- River Mile Post
- Municipalities
- Navigation Channel

Change in Depth (feet)

- < -9 (Heavy Scour)
- -9 - -7
- -7 - -5
- -5 - -3
- -3 - -1
- -1 - 1 (Neutral)
- 1 - 3
- 3 - 5
- 5 - 7
- 7 - 9
- > 9 (Heavy Deposition

Data Sources:
1. 1995 - 1997 Digital Orthophotos (NJDEP)
2. USACE/TGVEA 1989 Bathymetric Survey Points
3. USACE 2004 Bathymetric Survey Points

Coordinate System: State Plane New Jersey
Horizontal Datum: NAD 83
Vertical Datum: NGVD 29
Units: Feet

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The change in depth was calculated by subtracting the 1989 raster surface from the 2004 raster surface.

0 250 500 1,000

1 " equals 500 '

Plate 41: Mile 5 to 6

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Lower Passaic River, New Jersey

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1989 - 2004 Change in River Depth

Map Document: (S:\Projects\PASSAIC\MapDocuments\MXD\1989-2004 Bathymetry\Bathymetry_comparison_mapbook.mxd)
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Lower Passaic River, New Jersey

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1989 - 2004 Change in River Depth

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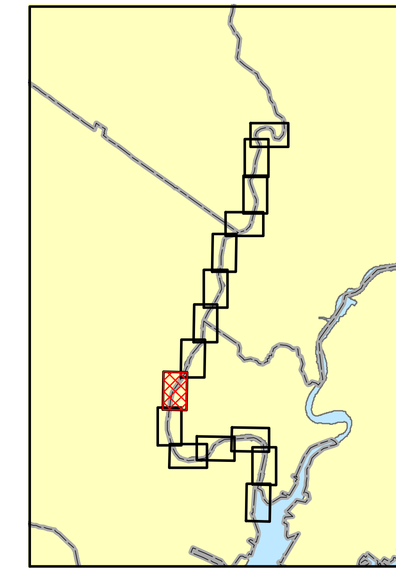

Legend

- River Centerline
- River Mile Post
- Municipalities
- Navigation Channel

Change in Depth (feet)

- < -9 (Heavy Scour)
- -9 - -7
- -7 - -5
- -5 - -3
- -3 - -1
- -1 - 1 (Neutral)
- 1 - 3
- 3 - 5
- 5 - 7
- 7 - 9
- > 9 (Heavy Deposition)

Data Sources:
1. 1995 - 1997 Digital Orthophotos (NJDEP)
2. USACE/TGVEA 1989 Bathymetric Survey Points
3. USACE 2004 Bathymetric Survey Points

Coordinate System: State Plane New Jersey
Horizontal Datum: NAD 83
Vertical Datum: NGVD 29
Units: Feet

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The change in depth was calculated by subtracting the 1989 raster surface from the 2004 raster surface.

0 250 500 1,000

1 " equals 500 '

Plate 42: Mile 6 to 7

Map Document: (S:\Projects\PASSAIC\MapDocuments\MXD\1989-2004 Bathymetry\Bathymetry_comparison_mapbook.mxd)
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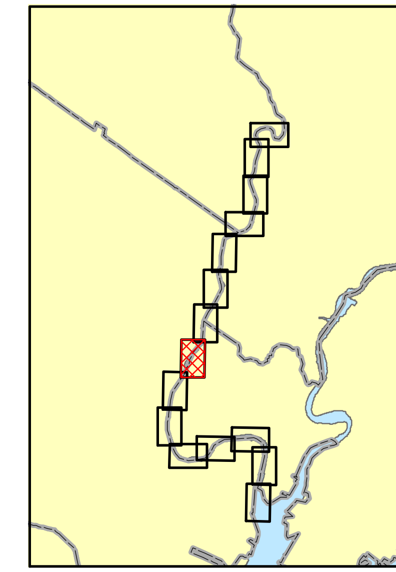

Legend

River Centerline
River Mile Post
Municipalities
Navigation Channel

Change in Depth (feet)
< -9 (Heavy Scour)
-9 - -7
-7 - -5
-5 - -3
-3 - -1
-1 - 1 (Neutral)
1 - 3
3 - 5
5 - 7
7 - 9
> 9 (Heavy Deposition

Data Sources:
1. 1995 - 1997 Digital Orthophotos (NJDEP)
2. USACE/TGVEA 1989 Bathymetric Survey Points
3. USACE 2004 Bathymetric Survey Points

Coordinate System: State Plane New Jersey
Horizontal Datum: NAD 83
Vertical Datum: NGVD 29
Units: Feet

Sounding depths from the 1989 Survey were converted from USACE Mean Low Water (MLW) to NGVD29 using a factor of 2.4 feet downstream of River Mile 6.8 and 2.3 feet upstream of River Mile 6.8.

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The change in depth was calculated by subtracting the 1989 raster surface from the 2004 raster surface.

0 250 500 1,000

1 " equals 500 '

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Lower Passaic River, New Jersey

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1989 - 2004 Change in River Depth

Plate 43: Mile 7 to 8

Map Document: (S:\Projects\PASSAIC\MapDocuments\MXD\1989-2004 Bathymetry\Bathymetry_comparison_mapbook.mxd)
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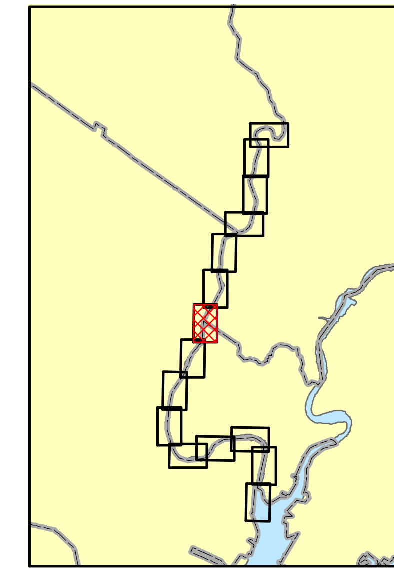
592000



Legend

- River Centerline
- River Mile Post
- Municipalities
- Navigation Channel

Change in Depth (feet)

- < -9 (Heavy Scour)
- -9 - -7
- -7 - -5
- -5 - -3
- -3 - -1
- -1 - 1 (Neutral)
- 1 - 3
- 3 - 5
- 5 - 7
- 7 - 9
- > 9 (Heavy Deposition)

Data Sources:
1. 1995 - 1997 Digital Orthophotos (NJDEP)
2. USACE/TGVEA 1989 Bathymetric Survey Points
3. USACE 2004 Bathymetric Survey Points

Coordinate System: State Plane New Jersey
Horizontal Datum: NAD 83
Vertical Datum: NGVD 29
Units: Feet

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The change in depth was calculated by subtracting the 1989 raster surface from the 2004 raster surface.

0 250 500 1,000

1 " equals 500 '

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Lower Passaic River, New Jersey

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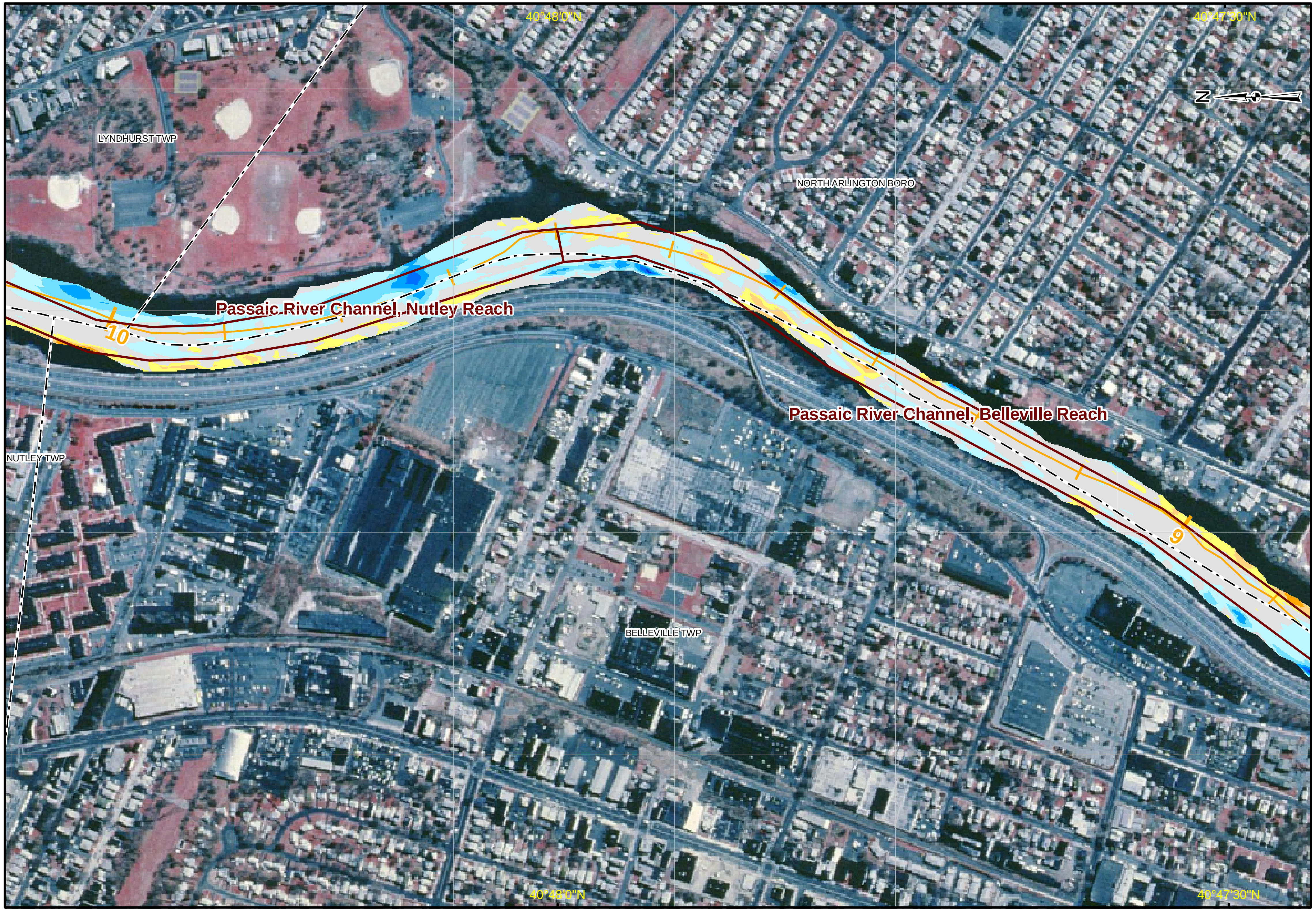
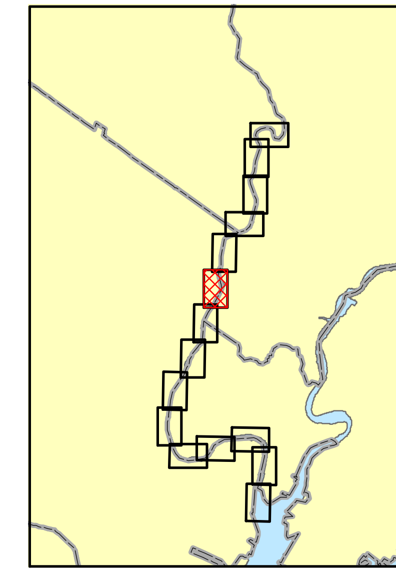
1989 - 2004 Change in River Depth

Plate 44: Mile 8 to 9

Map Document: (S:\Projects\PASSAIC\MapDocuments\MXD\1989-2004 Bathymetry\Bathymetry_comparison_mapbook.mxd)
03/08/2005 -- 1:22:28 PM





Legend

- River Centerline
- River Mile Post
- Municipalities
- Navigation Channel

Change in Depth (feet)

- < -9 (Heavy Scour)
- -9 - -7
- -7 - -5
- -5 - -3
- -3 - -1
- -1 - 1 (Neutral)
- 1 - 3
- 3 - 5
- 5 - 7
- 7 - 9
- > 9 (Heavy Deposition

Data Sources:
1. 1995 - 1997 Digital Orthophotos (NJDEP)
2. USACE/TGVEA 1989 Bathymetric Survey Points
3. USACE 2004 Bathymetric Survey Points

Coordinate System: State Plane New Jersey
Horizontal Datum: NAD 83
Vertical Datum: NGVD 29
Units: Feet

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The change in depth was calculated by subtracting the 1989 raster surface from the 2004 raster surface.

0 250 500 1,000

1 " equals 500 '

Investigation and Feasibility Study for Remediation and Restoration
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1989 - 2004 Change in River Depth

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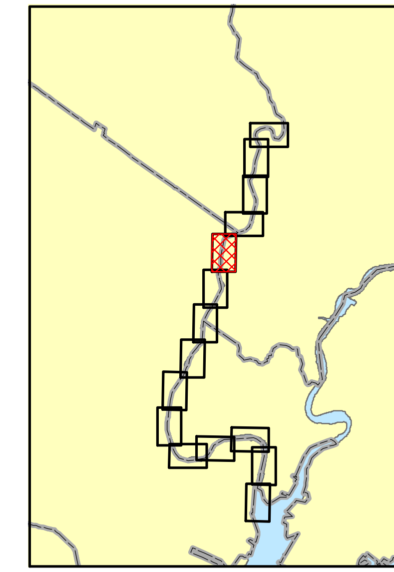
Plate 45: Mile 9 to 10

Map Document: (S:\Projects\PASSAIC\MapDocuments\MXD\1989-2004 Bathymetry\Bathymetry_comparison_mapbook.mxd)
03/08/2005 -- 1:22:28 PM



Legend

- River Centerline
- River Mile Post
- Municipalities
- Navigation Channel

Change in Depth (feet)

- < -9 (Heavy Scour)
- -9 - -7
- -7 - -5
- -5 - -3
- -3 - -1
- -1 - 1 (Neutral)
- 1 - 3
- 3 - 5
- 5 - 7
- 7 - 9
- > 9 (Heavy Deposition

Data Sources:
1. 1995 - 1997 Digital Orthophotos (NJDEP)
2. USACE/TGVEA 1989 Bathymetric Survey Points
3. USACE 2004 Bathymetric Survey Points

Coordinate System: State Plane New Jersey
Horizontal Datum: NAD 83
Vertical Datum: NGVD 29
Units: Feet

Sounding depths from the 1989 Survey were converted from USACE Mean Low Water (MLW) to NGVD29 using a factor of 2.4 feet downstream of River Mile 6.8 and 2.3 feet upstream of River Mile 6.8.

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The change in depth was calculated by subtracting the 1989 raster surface from the 2004 raster surface.

0 250 500 1,000

1 " equals 500 '

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Lower Passaic River, New Jersey

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1989 - 2004 Change in River Depth

Plate 46: Mile 10 to 11

Map Document: (S:\Projects\PASSAIC\MapDocuments\MXD\1989-2004 Bathymetry\Bathymetry_comparison_mapbook.mxd)
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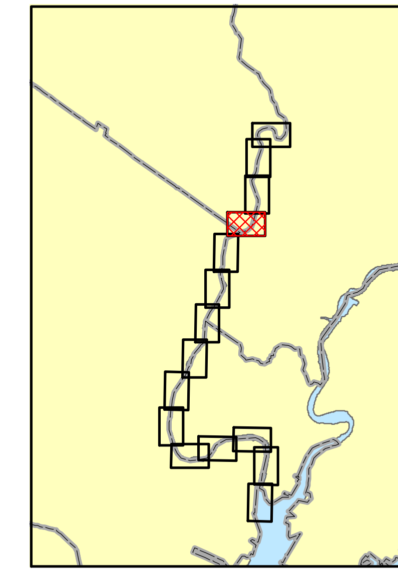

Legend

River Centerline
River Mile Post
Municipalities
Navigation Channel

Change in Depth (feet)
< -9 (Heavy Scour)
-9 - -7
-7 - -5
-5 - -3
-3 - -1
-1 - 1 (Neutral)
1 - 3
3 - 5
5 - 7
7 - 9
> 9 (Heavy Deposition)

Data Sources:
1. 1995 - 1997 Digital Orthophotos (NJDEP)
2. USACE/TGVEA 1989 Bathymetric Survey Points
3. USACE 2004 Bathymetric Survey Points

Coordinate System: State Plane New Jersey
Horizontal Datum: NAD 83
Vertical Datum: NGVD 29
Units: Feet

Sounding depths from the 1989 Survey were converted from USACE Mean Low Water (MLW) to NGVD29 using a factor of 2.4 feet downstream of River Mile 6.8 and 2.3 feet upstream of River Mile 6.8.

A Triangulated Irregular Network (TIN) was derived from the survey points for each dataset using ESRI's 3-D Analyst in ArcGIS. Contours were interpolated from the TIN, also in 3-D Analyst. Each surface was converted to a raster with a 5-foot grid cell size.

The change in depth was calculated by subtracting the 1989 raster surface from the 2004 raster surface.

0 250 500 1,000

1 " equals 500 '

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Investigation and Feasibility Study for Remediation and Restoration
Lower Passaic River, New Jersey

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1989 - 2004 Change in River Depth

Plate 47: Mile 11 to 12

Map Document: (S:\Projects\PASSAIC\MapDocuments\MXD\1989-2004 Bathymetry\Bathymetry_comparison_mapbook.mxd)
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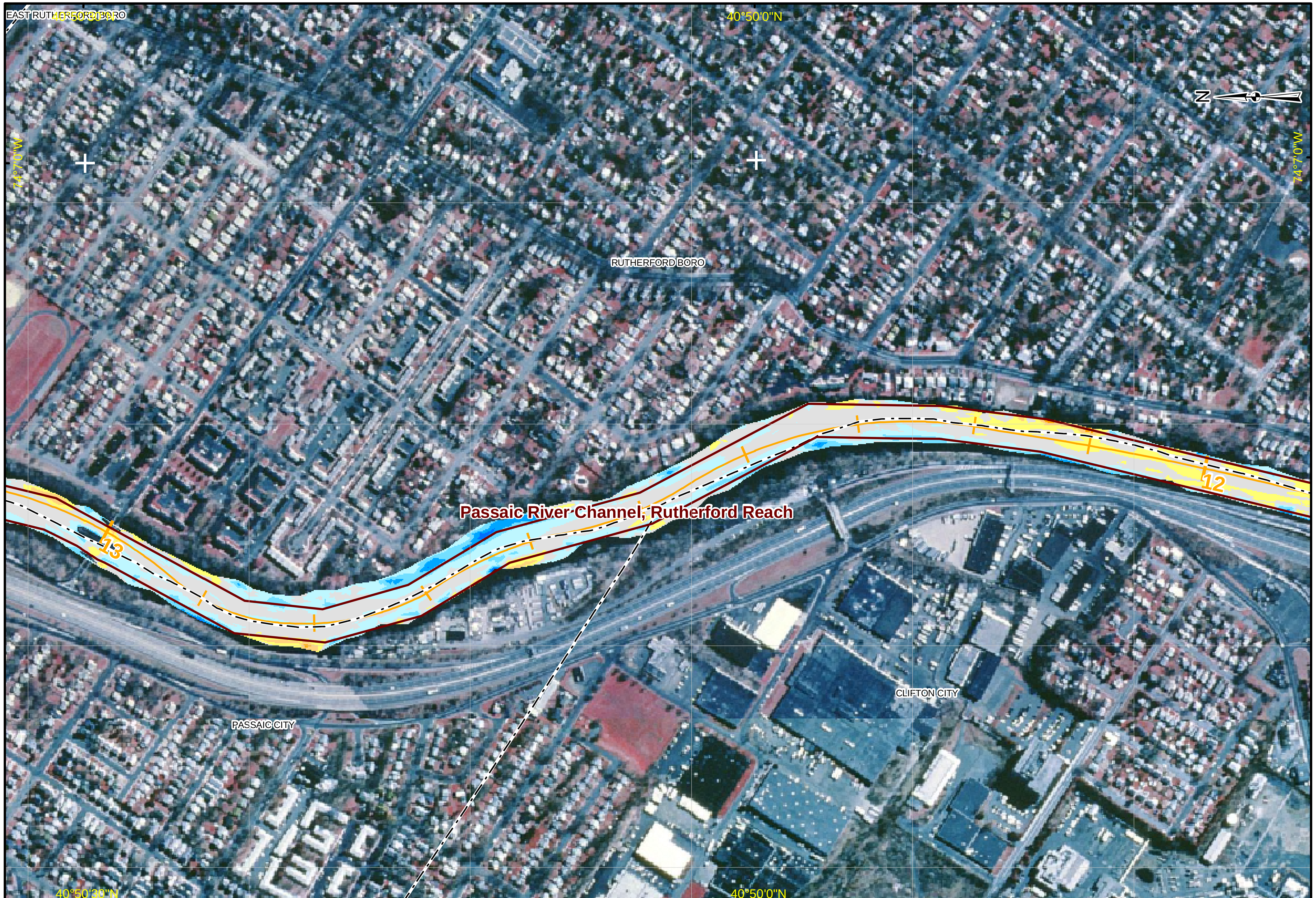

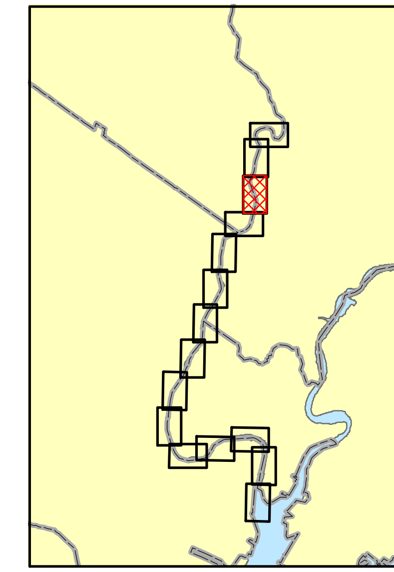

Legend

- River Centerline
- River Mile Post
- Municipalities
- Navigation Channel

Change in Depth (feet)

- < -9 (Heavy Scour)
- -9 - -7
- -7 - -5
- -5 - -3
- -3 - -1
- -1 - 1 (Neutral)
- 1 - 3
- 3 - 5
- 5 - 7
- 7 - 9
- > 9 (Heavy Deposition

Data Sources:
1. 1995 - 1997 Digital Orthophotos (NJDEP)
2. USACE/TGVEA 1989 Bathymetric Survey Points
3. USACE 2004 Bathymetric Survey Points

Coordinate System: State Plane New Jersey
Horizontal Datum: NAD 83
Vertical Datum: NGVD 29
Units: Feet

Sounding depths from the 1989 Survey were converted from USACE Mean Low Water (MLW) to NGVD29 using a factor of 2.4 feet downstream of River Mile 6.8 and 2.3 feet upstream of River Mile 6.8.

A Triangulated Irregular Network (TIN) was derived from the survey points for each dataset using ESRI's 3-D Analyst in ArcGIS. Contours were interpolated from the TIN, also in 3-D Analyst. Each surface was converted to a raster with a 5-foot grid cell size.

The change in depth was calculated by subtracting the 1989 raster surface from the 2004 raster surface.

0 250 500 1,000

1 " equals 500 '

Plate 48: Mile 12 to 13

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1989 - 2004 Change in River Depth

Map Document: (S:\Projects\PASSAIC\MapDocuments\MXD\1989-2004 Bathymetry\Bathymetry_comparison_mapbook.mxd)
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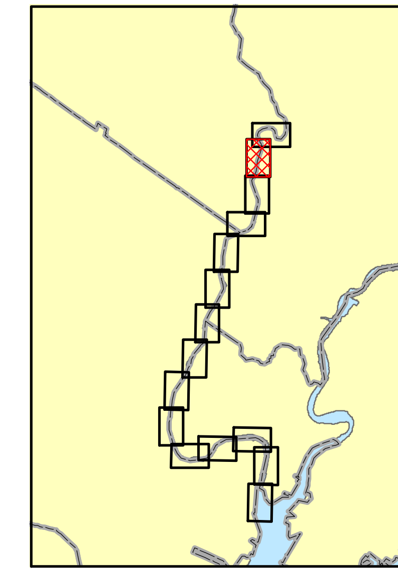

Legend

- River Centerline
- River Mile Post
- Municipalities
- Navigation Channel

Change in Depth (feet)

- < -9 (Heavy Scour)
- -9 - -7
- -7 - -5
- -5 - -3
- -3 - -1
- -1 - 1 (Neutral)
- 1 - 3
- 3 - 5
- 5 - 7
- 7 - 9
- > 9 (Heavy Deposition)

Data Sources:
1. 1995 - 1997 Digital Orthophotos (NJDEP)
2. USACE/TGVEA 1989 Bathymetric Survey Points
3. USACE 2004 Bathymetric Survey Points

Coordinate System: State Plane New Jersey
Horizontal Datum: NAD 83
Vertical Datum: NGVD 29
Units: Feet

Sounding depths from the 1989 Survey were converted from USACE Mean Low Water (MLW) to NGVD29 using a factor of 2.4 feet downstream of River Mile 6.8 and 2.3 feet upstream of River Mile 6.8.

A Triangulated Irregular Network (TIN) was derived from the survey points for each dataset using ESRI's 3-D Analyst in ArcGIS. Contours were interpolated from the TIN, also in 3-D Analyst. Each surface was converted to a raster with a 5-foot grid cell size.

The change in depth was calculated by subtracting the 1989 raster surface from the 2004 raster surface.

0 250 500 1,000

1 " equals 500 '

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1989 - 2004 Change in River Depth

Plate 49: Mile 13 to 14

Map Document: (S:\Projects\PASSAIC\MapDocuments\MXD\1989-2004 Bathymetry\Bathymetry_comparison_mapbook.mxd)
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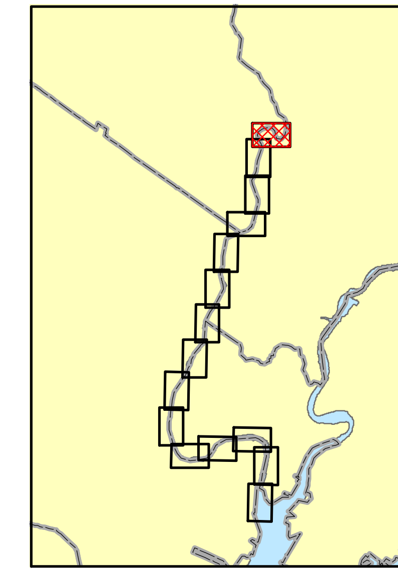

Legend

River Centerline
River Mile Post
Municipalities
Navigation Channel

Change in Depth (feet)
- < -9 (Heavy Scour)
- -9 - -7
- -7 - -5
- -5 - -3
- -3 - -1
- -1 - 1 (Neutral)
- 1 - 3
- 3 - 5
- 5 - 7
- 7 - 9
- > 9 (Heavy Deposition)

Data Sources:
1. 1995 - 1997 Digital Orthophotos (NJDEP)
2. USACE/TGVEA 1989 Bathymetric Survey Points
3. USACE 2004 Bathymetric Survey Points

Coordinate System: State Plane New Jersey
Horizontal Datum: NAD 83
Vertical Datum: NGVD 29
Units: Feet

Sounding depths from the 1989 Survey were converted from USACE Mean Low Water (MLW) to NGVD29 using a factor of 2.4 feet downstream of River Mile 6.8 and 2.3 feet upstream of River Mile 6.8.

A Triangulated Irregular Network (TIN) was derived from the survey points for each dataset using ESRI's 3-D Analyst in ArcGIS. Contours were interpolated from the TIN, also in 3-D Analyst. Each surface was converted to a raster with a 5-foot grid cell size.

The change in depth was calculated by subtracting the 1989 raster surface from the 2004 raster surface.

0 250 500 1,000

1 " equals 500 '

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1989 - 2004 Change in River Depth

Plate 50: Mile 14 to 15

Map Document: (S:\Projects\PASSAIC\MapDocuments\MXD\1989-2004 Bathymetry\Bathymetry_comparison_mapbook.mxd)
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